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Postpartum Dietary Changes in Women with Previous Gestational Diabetes

by

Keri Lynn Fehler

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Science

in

Nutrition and Metabolism

Department of Agricultural, Food and Nutritional Science

Edmonton, Alberta

Fall, 2003

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Faculty of Graduate Studies and Research

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Approved by Committee: Sept 12/2003

ABSTRACT

Women with Gestational Diabetes Mellitus (GDM) are at high risk of developing Type 2 Diabetes. This study was conducted to determine whether nutrition education obtained upon diagnosis of GDM resulted in dietary change and if this change was sustained postpartum. Women with GDM / IGT during pregnancy (≤32 weeks gestation) (n=19) were recruited and 4-day food records were collected pre-dietary intervention, 2 weeks post-dietary intervention, 6 weeks and 6 months postpartum. Food records were analyzed using the Food Processor 7.5. Data was analyzed by one-way repeated measures ($P<0.05$). Results indicate that after nutrition education there was a significant increase in protein (% Kcal), milk and milk products (serving), dietary fibre (g) intakes, and meal frequency (number of meals/day). Significant increases of these variables were not subsequently sustained throughout the postpartum period. Nutrition education during the postpartum period for women with GDM may be necessary to sustain changes made during pregnancy.

ACKNOWLEDGEMENTS

I would first like to thank the Canadian Diabetes Association for providing the funding for this research study.

Secondly, it is of most importance that I thank the nineteen study participants who so willingly took part in this study. Thank you for allowing me the opportunity to get to know you and learn so much from you all.

A very special thanks goes to my supervisor, Dr. Linda McCargar, for her ongoing support and encouragement throughout this research project. Thank you so much for sharing your kindness and expertise and encouraging me to be a confident researcher. And to Dr. Edmond Ryan who gave me the great opportunity to study this topic, which I've become so engaged in, not only personally but also professionally. Your expertise and dedication in this area of study has inspired me greatly.

To all those people who have so generously contributed their time and knowledge to this research project: Dr. Rhonda Bell, Dr. E. Romaniuk, Mary Pick, Stefanie Alloway, Julie Laverdiere, Jody Forslund, as well as the staff at the Northern Alberta Clinical Trials Research Centre, and the Royal Alexandra and Grey Nuns Hospital Diabetes Clinics.

And to Mark whose given me so much guidance and friendship. It has been a pleasure working alongside you.

To my family who has supported me over the years in my, at times, seemingly endless pursuit of education. Thank you for allowing me to find my own way and be the best I can be.

And finally to Darren, who has given me boundless encouragement throughout my graduate program. You've shown such patience and confidence in me to pursue my dreams while giving me such inspiration. Your love and devotion will always be cherished.

TABLE OF CONTENTS

CHAPTER ONE: INTRODUCTION 1
- A. Rational 1
- B. Purpose 3
- C. Hypotheses 3
- D. Research Question 3
- E. Objectives 3

CHAPTER TWO: LITERATURE REVIEW 5
- A. Gestational Diabetes Mellitus 5
  - 1. Complications 6
  - 2. Screening and Diagnosis 13
  - 3. Management of Gestational Diabetes Mellitus 14
    - a. Antepartum Management 15
    - b. Postpartum Management 30
  - 4. Summary of Literature 33

CHAPTER THREE: EXPERIMENTAL DESIGN & METHODOLOGY 34
- A. Experimental Design 34
  - 1. Screening Component 34
  - 2. Study Protocol 37
  - 3. Intervention Component 39
- B. Methodology 40
  - 1. Dependent Measures 40
    - a. *Dietary Intake* 40
    - b. *Postpartum Weight Management and Body Composition* 43
    - c. *Measurement to Determine Risk of Diabetes* 45
    - d. *Physical Activity* 46
- C. Statistical Analysis of Results 46

CHAPTER FOUR: RESULTS 49
- A. Participant Recruitment 49
- B. Dependent Measures 51
  - 1. Main Results 51
    - a. *Dietary Intake* 52
    - b. *Postpartum Weight Management and Body Composition* 61
    - c. *Measurement to Determine Risk of Diabetes* 62
    - d. *Physical Activity* 66
- C. Summary of Results - Hypotheses and Research Question 69

CHAPTER FIVE: DISCUSSION 71
A. Major Findings 71
B. Participant Recruitment 71
C. Dependent Measures 73
D. Summary 83
E. Limitations of the Study 84
F. Future Research 84

LITERATURE CITED 86

APPENDICES 99

LIST OF TABLES

Table 1	Goals of Medical Nutrition Therapy Guidelines for GDM	17
Table 2	Glycemic Index (GI) Values	22
Table 3	Healthy Eating Index Scoring System based on 2200 Kcal/day	42
Table 4	General Characteristics of Study Participants	51
Table 5	Social Characteristics of Study Participants	51
Table 6	Dietary Intake of Calories, Macronutrients, and Fibre	53
Table 7	Dietary Intake of Macronutrients and Fibre Compared to the Dietary Reference Intakes (DRIs)	54
Table 8	Dietary Intake of Select Micronutrients	55
Table 9	Number of Study Participants Who Did Not Meet Recommended Dietary Allowances (RDA) of Select Micronutrients	56
Table 10	Meal Frequency, Intake of the Four Food Groups, and Healthy Eating Index (HEI) scores	58
Table 11	Number of Servings of the Food Groups Compared to Recommended Levels	59
Table 12	Summary of Key Dietary Variables	60
Table 13	Mean Weight Compared to Mean Prepregnancy Weight	61
Table 14	Mean BMI, Waist Circumference, and Percent Body Fat Compared to Normal Values	62
Table 15	Mean Fasting and 2-hour Serum Glucose	63
Table 16	Number of Study Participants Who Had Normal Blood Glucose Values and Those Who Met the Criteria For IFG, IGT, and DM	63
Table 17	Mean Fasting and 2-hour Serum Insulin	64
Table 18	Mean Fasting Serum Total Cholesterol, HDL, LDL, TG	65

Table 19 Number of Study Participants Who Did Not Meet Desirable Levels of Serum Lipids.....66

Table 20 Mean Scheduled Exercise Energy Expenditure.....67

Table 21 Frequency of Scheduled Daily Activity.....68

Table 22 Duration of Scheduled Daily Activity.....68

LIST OF FIGURES

Figure 1 Criteria for the Diagnosis of GDM in Canada using the 75 g glucose load OGTT.....14

Figure 2 Principles of Canada's Food Guide to Healthy Eating.....16

Figure 3 Target glucose values for GDM.....30

Figure 4 Study Protocol.....38

LIST OF APPENDICES

Appendix A – Canada's Food Guide to Healthy Eating.....99

Appendix B – Ethical Approval.....101

Appendix C - Information Sheet 102

Appendix D - Consent Form.....104

Appendix E – 4-day Food Record Diary Sample Day 1.....105

Appendix F – Lifestyle Questionnaire – Baseline.....106

Appendix G – 4-day Food Record Instruction Sheet.....109

Appendix H – Lifestyle Questionnaire – 6 weeks and 6 months postpartum.....110

Appendix I – Calculation of Type 1 Error Using paired T-tests.....116

ABREVIATIONS

ADA: American Diabetes Association

AI: Adequate Intake

bpm: Beats per Minute

BMI: Body Mass Index

CDA: Canadian Diabetes Association

DRI: Dietary Reference Intakes

FPG: Fasting Plasma Glucose

GDM: Gestational Diabetes Mellitus

GI: Glycemic Index

HDL-C: High Density Lipoproteins

HEI: Healthy Eating Index

IFG: Impaired Fasting Glucose

IGT: Impaired Glucose Tolerance

INT: Intensive Nutrition Therapy

LDL-C: Low Density Lipoproteins

LGA: Large for Gestational Age

MNT: Medical Nutrition Therapy

OGTT: Oral Glucose Tolerance Test

RDA: Recommended Dietary Allowances

SD: Standard Deviation

SMBG: Self-Monitoring of Blood Glucose

TC: Total Cholesterol

TG: Triglycerides

Postpartum Dietary Changes in Women with Previous Gestational Diabetes

Chapter One: Introduction

A. RATIONALE

Gestational Diabetes Mellitus (GDM) is defined as any abnormal carbohydrate intolerance first recognised during pregnancy (American Diabetes Association, 1999) and it occurs in 2 to 4% of the population who are pregnant (Engelgau, Herman, Smith, German, & Aubert, 1995; Canadian Diabetes Association,1998). Higher prevalence rates have been reported in higher risk ethnic groups such as Aboriginal Canadians (Forsbach, Conteras Soto, Fong, Flores, & Moreno, 1988; Harris, Caulifield, Sugamouri, Whalen, & Henning, 1997). GDM is associated with short-term and long-term risks to both the fetus and the mother. Risks to the fetus include macrosomia, hypoglycemia and jaundice at birth, and increased susceptibility to glucose intolerance and obesity in the longterm. The mother has increased risk of developing Type 2 Diabetes later in life. The risk of developing diabetes postpartum is approximately 50% and the risk of developing impaired glucose tolerance can be as high as 75% (Ryan, 2001; Kjos et al, 1995; Pallardo et al, 1999; Ali & Alexis, 1990). It is known that alterations to both insulin sensitivity and insulin secretion play a role in the risk of developing diabetes for women with GDM (Ryan et al, 1995). Risk factors for the progression to diabetes include: increased prepregnancy body mass index (BMI), severity of glucose intolerance during pregnancy, presence of increased glucose values at postpartum oral glucose tolerance tests (OGTT), increasing age, and a family history of diabetes (Dornhorst & Frost, 1997; Ryan, 2001).

Research has shown that weight loss achieved by consuming low fat and high carbohydrate, high fibre diets, and increased physical activity, improves insulin sensitivity and decreases the risk of diabetes (Dornhorst & Frost, 1997; Hu et al, 2001). Tuomilehto et al (2001) have shown that it is possible to prevent type 2 diabetes in high risk individuals by providing longterm follow up and individualized counselling focused on weight reduction. This was facilitated by reduced dietary fat and increased fibre intakes, and increased physical activity. More recently, a study completed by the Diabetes Prevention Program Research Group (2002) demonstrated that intensive lifestyle intervention targeted at high risk groups reduced the incidence of diabetes by 58% as compared to the placebo group. The lifestyle intervention included 16 weeks of one-to-one counselling aimed at a minimum of 150 minutes of moderate physical activity per week and healthy low calorie diets low in fat.

Upon diagnosis, women with GDM receive intensive diabetes education. This includes strategies for dietary and lifestyle modifications, information on achieving glycemic control, and in some cases, insulin therapy (Canadian Diabetes Association, 1991). It is during pregnancy that women with GDM should be encouraged to continue diet and lifestyle changes made during gestation, and over the long-term, to aid in prevention of the future development of diabetes (Neilson & Tapsell, 1994). There is little research to date to determine whether lifestyle modifications, such as diet and exercise, initiated upon diagnosis of GDM are achieved and subsequently sustained throughout the postpartum period. Furthermore, the impact of these lifestyle choices on subsequent health outcomes has not been extensively studied.

B. PURPOSE

The purpose of this study was to determine whether nutrition education provided upon diagnosis of GDM or IGT during pregnancy resulted in dietary modification and if this was sustained postpartum. The secondary purpose was to investigate the presence of risk factors for diabetes during the postpartum period.

C. HYPOTHESES

Women with GDM or IGT during pregnancy who receive nutrition education at diagnosis will make short-term* changes that will improve dietary intake and be sustained over the longterm* in;

a) key diabetes related variables such as: amount, type, distribution and proportion of carbohydrates.

b) key pregnancy and postpartum related variables: protein, calcium, folate, iron and Vitamin D, and the four food groups from the Canada Food Guide.

(*Short-term=post-intervention; Long-term=postpartum)

D. RESEARCH QUESTION

Will women with GDM or IGT during pregnancy who receive nutrition education at diagnosis achieve normal values within the first 6 months postpartum for several of the risk factors for developing diabetes: weight management, fasting serum glucose, serum insulin, and serum lipids during the postpartum period?

E. OBJECTIVES

1. Hypothesis 1 a) and 1 b) were tested by assessing 4 day food records of dietary intake twice during pregnancy and at 6 weeks, and 6 months postpartum of study participants with GDM or IGT during pregnancy.

2. The Research Question investigating the risk of developing diabetes in women with GDM or IGT during pregnancy within the first 6 months postpartum, was assessed by using the following anthropometric and biochemical measurements:
   a) weight (kg), height (cm), and BMI (kg/m^2).
   b) serum glucose, using the 75 g load oral glucose tolerance test (OGTT)
   c) serum insulin, fasting and 2-hour post 75 g load OGTT
   d) lipid values, including total cholesterol, HDL-C, LDL-C, TG.

Chapter Two:
Literature Review

A. Gestational Diabetes Mellitus

Gestational Diabetes Mellitus (GDM) is defined as any abnormal carbohydrate intolerance first recognised during pregnancy (American Diabetes Association, 1999). It is due to the combination of insulin resistance and a defect in insulin secretion. Pregnancy is associated with many hormonal changes that affect carbohydrate metabolism. Both estrogen and progesterone levels affect insulin balance throughout pregnancy (Ryan & Enns, 1988) however, in the second trimester it is the rise in cortisol, prolactin, and particularly human placental lactogen (hPL), that ultimately leads to insulin resistance (Ryan & Enns, 1988; Kuhl, 1998) and glucose tolerance decreases. During a normal pregnancy the increase in insulin resistance is compensated for by the pancreas, which secretes more insulin. However, in women with GDM, underlying beta cell defects prevent this from occurring (Kautsky-Willer et al, 1997; Bowes et al, 1996). Upon delivery, most women with GDM regain normal blood glucose levels but exhibit abnormal insulin secretion and action (Ryan et al, 1995).

GDM is associated with neonatal macrosomia and hypoglycemia and the mother is at increased risk of developing Type 2 diabetes. This risk of developing diabetes postpartum is approximately 50% and the risk of developing impaired glucose tolerance can be as high as 75% (Ryan, 2001; Kjos et al, 1995; Pallardo et al, 1999; Ali & Alexis, 1990). Impaired glucose tolerance (IGT), sometimes referred to as pre-diabetes, is a condition where blood glucose levels are higher than normal but not high enough to be diagnosed as diabetes (IGT can be diagnosed when fasting plasma glucose is less than 7.0

mmol/L but falls between 7.8 and 11.0 mmol/L 2 hours after a 75 glucose load) (CDA, 1998). People with IGT have a higher risk of diabetes and cardiovascular disease than do the general population (CDA, 1998). In addition, recent reviews of the classification of Diabetes Mellitus prompted another category termed impaired fasting glucose (IFG) targeting those individuals at higher risk of abnormal glucose tolerance with a fasting glucose of 6.1 to 6.9 mmol/L (CDA, 1998). Risk factors for GDM include: increasing age, a family history of diabetes, increasing obesity, especially in early adulthood, ethnicity (risk in descending order: Asians, Hispanics, African Americans, Aboriginals, and Caucasians), and cigarette smoking (Solomon et al, 1997). GDM occurs in 2 to 4% of pregnancies (Engelgau et al., 1995; Xiong, Saunders, Wang, & Demianczuk, 2001) and is found to be twice this in Aboriginal Canadian populations (Harris et al, 1997). However, prevalence rates differ widely among countries largely due to varying definitions used for the diagnosis of GDM.

1. Complications

a) Short-term Complications

i) Fetus

One of the most frequent fetal complications of GDM is macrosomia. Macrosomia can be defined as a birth weight greater than 4000g (Schwartz & Teramo, 1999). Another measure of macrosomia is if the newborn is large for gestational age (LGA), which is any birth weight greater than the 90th percentile, also >4500g. Macrosomia occurs in between 18 - 29% of GDM births and is more predominant in those women with GDM who are obese (Hod et al, 1996). Macrosomia is associated with

increased risk of asphyxia and birth trauma such as clavical fracture, shoulder dystocia, and brachial palsy.

Macrosomia, as hypothesized by Pederson, is due to fetal hyperinsulinemia most likely caused by an increase in maternal glucose being transmitted to the fetus via the placenta (Pederson, 1954). Maternal hyperglycemia is thought to lead to fetal hyperglycemia, which then results in the stimulation of fetal pancreatic β-cells to produce insulin. As a consequence, fetal hyperinsulinemia, increases anabolism and thus macrosomia ensues. Despite Pederson's hypothesis, studies have demonstrated that macrosomia has stronger associations with gestational age at birth, maternal weight gain, maternal pregravid weight, gender, and parity (Catalana, 1998; Breschi et al, 1993). However, management surrounds the treatment of maternal hyperglycemia, as this risk factor for macrosomia is the most adaptable (Ryan, 2001). Many studies have demonstrated that intensive management of GDM with tight blood glucose control decreases the occurrence of macrosomia and neonatal hypoglycemia (Langer et al, 1994; Thompson, Dansereau, Creed, and Ridell, 1994).

Hypoglycemia occurs in 3- 38% of infants born to women with GDM (Hod et al, 1996; Stenninger, Scholin, & Aman, 1991). The definition of neonatal hypoglycemia that is generally accepted is a blood glucose level of less than 1.7 mmol/L in term infants (Senior, 1973). Maternal blood glucose control is important during labour and delivery as maternal hyperglycemia during these processes is related to neonatal hypoglycemia (Langer et al, 1994; Thompson, Dansereau, Creed, and Ridell, 1994). As discussed previously, poor maternal glycemia leads to fetal hyperinsulinemia and an overproduction of insulin in response to the high levels of maternal glucose. Once the umbilical cord is

cut, so is the constant supply of the high level of maternal glucose, however, the fetal pancreas continues to produce high levels of insulin (Senior, 1973). Consequently, this combination of a low blood glucose supply and high insulin production results in neonatal hypoglycemia. Furthermore, neonatal hyperinsulinemia has also been linked to high amniotic fluid insulin levels in infants with macrosomia (Fraser & Bruce, 1999). It is recommended that the serum glucose level of the neonate be maintained at a level greater than 2.8 mmol/L (Schwartz, 1997).

Another common occurrence in newborns of women with GDM is jaundice, which has been shown to occur at a rate of 16% (Hod et al, 1991). Jaundice, or hyperbilirubinemia, occurs due to an immature hepatic system where unconjugated bilirubin pigment is deposited in the skin rather than being conjugated in the liver and excreted in the bile (Porter & Dennis, 2002). This condition can be treated with phototherapy to conjugate the bilirubin for excretion. Other conditions seen in the past that are now rare due to contemporary medical practices are; hypocalcemia, hypomagnesemia, polycythemia, respiratory distress syndrome, and myocardial hypertrophy (Weintrob, Karp, & Hod, 1996).

Typically, congenital malformations of the fetus occur at much higher rates in pregnant women with Type 1 or Type 2 diabetes, due to the exposure to hyperglycemia in the first trimester. However, because GDM is typically expressed in the second and third trimesters, congenital malformation rates are similar to those found in newborns of healthy pregnant women (Mironiuk, Kietlinska, Jerierska-Kasprzyk, & Piekosz-Orzechowska, 1997). Congenital malformations are more likely to be found in those women with GDM who have had either a very early or a severe onset of GDM or who

may have had undiagnosed Type 2 diabetes prior to becoming pregnant (Farrell, Neale, & Cundy, 2002; Bartha, Martinez-Del-Fresno, & Comino-Delgado, 2000). In fact, it is suggested that maternal fasting serum glucose concentration at diagnosis is a useful predictor of the risk for major complications in the offspring of women with diabetes which is first diagnosed during pregnancy (Schafer et al, 1997). Glucose results at diagnosis could potentially be used to guide counselling and treatment of the GDM patient.

ii) Mother

Research shows that there is an increased risk of Caesarean section (C-section) delivery in women with GDM (Remsberg, McKeown, McFarland, and Irwin, 1999). However, it has been demonstrated that this increased risk is not in direct relationship with birth size but rather with the patient being diagnosed with GDM (Hod et al, 1996). Controversy exists regarding this issue, as some believe that labelling patients with GDM automatically classifies them in a category for a C-section delivery (Remsberg et al, 1999; Naylor, Sermer, Chen, and Sykora, 1996).

b) Long-term complications

i) Fetus

Obesity and impaired glucose tolerance (IGT) are long-term complications in the offspring of women with GDM. Extending Pederson's hypothesis, Freinkel (1980) first hypothesized that an abnormal fetal metabolic environment would have long-term effects on the growth and metabolic development of a child. It is difficult to distinguish between

the effects of genetics and the in utero environment. However, studies done by Pettit, Bennett, Knowler, Baird, and Aleck (1985) of the Pima Indians have demonstrated that exposure to hyperglycemia during gestation appears to have long-term effects leading to obesity and glucose intolerance in the offspring. Offspring between the ages of 5 –19 years of women with abnormal glucose tolerance during pregnancy were more obese and had higher glycemia two-hour post glucose load than those offspring of women with normal glucose tolerance during pregnancy. This would indicate that there are aspects of the in utero environment, perhaps in addition to the genetic component, that affects anthropometric and metabolic status of the offspring in their later years of life.

Two similar studies further indicate maternal hyperglycemia and fetal hyperinsulinemia present in utero, lead to impaired glucose tolerance in the offspring of women with pregestational or gestational diabetes (Silverman, Metzger, Cho, & Loeb, 1995; Plagemann, Harder, Kohlhoff, Rohde, & Dorner, 1997). Fetal insulin secretion measured in the amniotic fluid was a strong predictor of IGT in both studies. In addition, both increased maternal prepregnancy adiposity and the in utero environment of hyperglycemia are associated with increased adiposity in the offspring (Vohr, McGarvey, & Tucker, 1999).

ii) Mother

The recurrence rate for GDM in subsequent pregnancies ranges from 30% to 50% (Moses, 1996; Philipson & Super, 1989; Gaudier, Hauth, Poist, Corbett, & Cliver, 1992). This risk tends to be the highest in Asians, Hispanic, African American, older women, and those women who gain weight between pregnancies.

Of major concern is the long-term risk of developing Type 2 diabetes postpartum. Approximately half the women with GDM will develop Type 2 diabetes within 15 years postpartum (O'Sullivan, 1982; Zulaika & Alexis, 1990; Kjos et al, 1995; Steinhart, Sugarman, & Connell, 1997). This risk is based on the underlying alterations of insulin action and insulin secretion relating to ß-cell dysfunction (Ryan et al, 1995). There are several factors that are predictive of developing Type 2 diabetes in women with GDM such as increased prepregnancy BMI, the severity of glucose intolerance during pregnancy, and the presence of high glucose values determined by a postpartum OGTT (Dornhorst & Rossi, 1998).

Increased prepregnancy weight is one of the major predictors of Type 2 diabetes in women with GDM (Metzger, Cho, Roston, & Radvany, 1993; O'Sulivan, 1982). In a five-year follow up study, Metzger et al (1993), found that 50% of the women with GDM developed Type 2 diabetes where prepregnancy weight was one of the independently associated risk factors. Other studies have also supported the finding that increased prepregnancy weight and body mass index (BMI) are predictive of later onset of Type 2 diabetes in women with GDM (Catalano, Vargo, Berstein, & Amini, 1991; Coustan, Carpenter, O'Sullivan, & Carr, 1993; Damm, Kuhl, Bertelsen, & Molsted-Pedersen, 1992). In addition, the degree of obesity in the postpartum period is a major determinant of the severity of subsequent insulin sensitivity (O'Sulivan, 1982). Postpartum weight control would appear to be an important modifiable risk factor in preventing Type 2 diabetes in the postpartum period.

Another predictor of Type 2 diabetes is the severity of glucose intolerance during pregnancy as assessed by the early onset of GDM, elevated fasting plasma glucose and

the need for insulin therapy. Kjos et al (1990), found that the prevalence of Type 2 diabetes increased with the degree of maternal glucose intolerance. The more severe the glucose intolerance during the index pregnancy the greater the risk of developing Type 2 diabetes in the postpartum period.

Gestational age of <24 weeks at diagnosis was found to be a risk factor for postpartum glucose intolerance (Kjos et al, 1990; Catalano et al, 1991; Kjos et al, 1995). Fasting plasma glucose (FPG) during pregnancy is highly predictive of postpartum diabetes (Catalano et al, 1991). Damm et al (1992), found that a fasting plasma glucose of >5 mmol/L at diagnosis of GDM was predictive of the development of postpartum diabetes. Similarly, Metzger et al (1993), found that approximately 75% of those women who had a FPG of >7.2 mmol/L at diagnosis of GDM developed postpartum diabetes within 5 years compared to 10% of women with FPG values of <5.8 mmol/L. In addition, impaired insulin secretion at diagnosis as measured by antepartum OGTT exhibits the level of ß-cell dysfunction in women with GDM and predicts diabetes within 5-10 years postpartum (Metzger et al, 1993; Damm et al, 1992). The need for insulin therapy is another predictive factor for the development of postpartum diabetes in women with GDM (Catalano et al, 1991). It was found that 78% of the women with abnormal postpartum glucose tolerance required insulin therapy during pregnancy compared to 40% of the women with normal postpartum glucose tolerance. Finally, the presence of high plasma glucose levels on postpartum OGTT (Figure 1) also indicates a risk of developing diabetes.

2. Screening and Diagnosis

All women should be screened for GDM between the 24th and 28th week of gestation except those in the very low risk group (CDA, 1998).

Low risk group includes:

Prepregnancy BMI <25

<25 years of age

No personal or familial history of diabetes

Not of Hispanic, African-American, Aboriginal or Asian descent

The optimal screening test used in Canada and the US is the measurement of plasma glucose level 1 hour after a 50g oral glucose load taken at any time during the day (CDA, 1998; ADA, 1998).

If the 1 hour plasma glucose is;

≥7.8 mmol/L, a glucose tolerance test should be performed to verify a diagnosis of GDM

≥10.3 mmol/L, GDM can be confidently diagnosed without an OGTT

Worldwide criteria for the diagnosis of GDM remains quite variable, however, the criteria used in Canada and the US are similar. Both countries have adopted the OGTT with the 75g glucose load, however, the US accepts both the 75g and the 100g oral glucose loads.

Figure 1
Criteria for the Diagnosis of GDM in Canada using the 75 g glucose load OGTT

If two out of the three criteria are met, GDM is diagnosed. If only one of the criteria is met the diagnosis of impaired glucose tolerance (IGT) of pregnancy is made:

Fasting	≥5.3 mmol/L
1 hour	≥10.6 mmol/L
2 hour	≥8.9 mmol/L

(CDA, 1998)

Should IGT be diagnosed, the World Health Organization suggests treating this condition similarly to GDM, although treatment protocols differ among diabetes clinics for this group (CDA, 1998). It is still unknown at what specific levels of glucose intolerance neonatal complications occur.

3. Management of Gestational Diabetes Mellitus

Gestational diabetes is a temporary condition by definition, but is associated with long lasting metabolic consequences well into the later stages of life. As such, its management requires immediate and long-term lifestyle and behaviour changes. Thus, its management can be divided into two parts: antepartum, and postpartum. Management during the antepartum period includes a) self-management skills; b) medical nutrition therapy (MNT); c) medication; d) regular physical activity; e) self-blood glucose monitoring and glycemic control.

a) Antepartum Management

i) Self-Management Skills

Once diagnosed with gestational diabetes, the individual is normally referred to a diabetes clinic where a team of health care professionals specializing in diabetes, including a physician, nurse and dietitian educate the individual on how to implement self-management into their lifestyles. Women are given the information and tools to help them manage their diabetes. Due to the short duration of GDM, pregnancy follow up visits are often quite frequent unless good glycemic control is maintained quickly and consistently.

ii) Medical Nutrition Therapy

Nutrition is one of the cornerstones in the management of diabetes. Widely accepted goals of nutrition therapy for women with GDM include:1) consuming a nutritionally adequate well balanced diet, 2) maintaining appropriate weight during pregnancy, while 3) achieving good glycemic control. Therefore, nutrition therapy is largely based on glycemic control and dependent on individual parameters, with consideration given to the individual's usual food intake, eating habits, and weight status.

Most women with GDM are treated with nutrition therapy alone. Important to note is that there is limited information available for evidence-based recommendations where specific nutrition guidelines can be used in the management of GDM (Metzger & Coustan, 1998; Dornhorst & Frost, 2002). Consequently, some of the current practices are "based largely on empirical evidence of practicing clinicians" (Gunderson, 1997). In the area of nutrition therapy, as in many other areas surrounding GDM, there are no universally accepted guidelines to which dietitians can refer. In Canada, nutrition therapy

for people with diabetes is the same as that for all healthy Canadians where the principles of Canada's Food Guide to Healthy Eating (Figure 2) are promoted providing guidelines for food group intakes (Canadian Diabetes Association, 1998). Additionally, the joint US/Canadian release of the DRI's suggest following the Acceptable Macronutrient Distribution Range (AMDR) for carbohydrates, fats and protein (Dietary Reference Intakes for Energy, Carbohydrates, Fat, Fibre, Protein and Amino Acids, 2002). These recommendations suggest intakes of approximately 45-65% kcal from carbohydrates; 20-35% kcal from fats (with <10% of total energy derived from saturated fatty acids), and 10-35% kcal from protein. Included in these recommendations are guidelines to incorporate approximately 14 g/1000kcal/day of total fiber. Goals for medical nutrition therapy for women with GDM are based upon good glycemic control achieved with general healthy eating while maintaining appropriate weight gain during pregnancy. Goals for medical nutrition therapy for people with GDM are similar to those outlined by both the CDA and ADA for people with diabetes (Table 1).

Figure 2
Principles of Canada's Food Guide to Healthy Eating.

Principles of Canada's Good Healthy Eating Guide:

- Enjoy a Variety of Foods.
- Emphasize cereals, breads and other whole grain products, vegetables and fruit.
- Choose lower-fat dairy products, leaner meats and foods prepared with little or no fat.
- Achieve and maintain a healthy body weight by enjoying regular physical activity and healthy eating.
- Limit salt, alcohol and caffeine.

Health and Welfare Canada, 1990.

Table 1
Goals of Medical Nutrition Therapy Guidelines for GDM.

Nutrition Therapy Guidelines	Pregnant	Nonpregnant
Energy Intake (Kcal) (Based on Prepregnancy weight)	24 Kcal/kg/d –at 120% body wt[1] 30 Kcal/kg/d – ideal body wt 40 Kcal/kg/d <80% body wt (generally 300 extra Kcal/day)	Dependent upon age, weight, height, and physical activity level
Carbohydrate (% Kcal)	45-65% % based on individual parameters and glycemic control	45-65%
Fat (%Kcal)	20-35% ≤10% saturated fat % based on individual parameters and glycemic control	20-35% ≤10% saturated fat
Protein (%Kcal or g/kg/d)	10-35% + an additional 25 g/day or 1.1g/kg/day	10-35% or 0.80 g/kg/day
Dietary Fibre (g)	Women (14-50 yrs) – 28 g or 14g/1000kcal/day	Women (19-50yrs) – 25 g or 14g/1000kcal/day
Calcium (mg)	1000 mg/ day (ages 19-50y)	1000 mg/ day (ages 19-50y)
Folate (mg)	0.4- 1.0 mg/day	0.4 mg/day
Iron (mg)	30 mg /day	18 mg /day
Vitamin/Mineral Supplementation	Not recommended unless insufficient in diet	Not recommended unless insufficient in diet
Meal Frequency	Suggest 6 small meals per day but to be determined based on individual parameters with small frequent meals being favoured	N/A
Weight Gain[2] (Based on Prepregnancy BMI)	BMI <20 – 12.5 – 18 Kg BMI 20-27 – 11.5 -16 Kg BMI > 27 – 7.0 – 11.5 Kg BMI >30 - at least 7.0 Kg	N/A

[1] Ideal body weight
[2]These guidelines apply only to singleton pregnancies.
(CDA, 1998; Manual of Clinical Dietetics, 2000; ADA, 2003; Fagen, King & Erick, 1995; Health Canada, 1999; Dietary Reference Intakes for Energy, Carbohydrates, Fibre, Fat, Protein and Amino Acids, 2002)

As GDM is typically diagnosed in the third trimester (24 to 28 weeks gestation), it is essential to begin nutrition therapy promptly. A meal plan is calculated based on

individual energy requirements as presented in Table 1 where the patient can make daily food choices from each food group. This meal plan should incorporate an appropriate balance of carbohydrates, protein and fat. Ongoing dietary adjustments are made based on postprandial glycemic control (Figure 3, Page 31) and weight gain (Table 1, Page 18) throughout pregnancy. Vitamin and mineral supplementation is generally not recommended other than iron, calcium, and folate as these needs are increased during pregnancy (CDA, 1998; ADA, 2003). People with diabetes are encouraged to obtain vitamin and mineral requirements by following Canada's Food Guide to Healthy Eating (Appendix A). However, when specific nutrient intakes are assessed to be insufficient, supplementation may complement daily intakes in achieving the nutrition recommendations (Health Canada, 1999).

Current controversial issues in nutrition therapy for GDM include: the amount, type, and distribution of carbohydrates, fat distribution, and the frequency of meals. At present, there is considerable emphasis being placed on the area of intensive nutrition therapy (INT), which refers to the controlled intake of the amount, type and distribution of carbohydrates while providing adequate caloric intake in women with GDM (Gunderson, 1997). It has been suggested that INT in combination with self-monitoring of blood glucose has the potential to replace insulin therapy in women with GDM, however, this has not been fully explored. Pregnancy outcomes in women with GDM treated with INT versus insulin therapy were compared from data provided from the Sweet Success Diabetes and Pregnancy Program based in California (Kitzmiller J, Hoedt L, Gunderson E, Theiss T, Ceresa C, Kitzmiller A, 1989). The frequency of LGA infants in the INT group was 11.5% compared to 23.7% for insulin therapy group.

Some experts suggest restricting the total amount of carbohydrates in the diet to 40-45% to achieve good glycemic control (Javanovic-Perterson & Peterson, 1990). Major, Henry, De Viciana and Morgan (1998) compared glucose tolerance during pregnancy and perinatal outcomes in women with GDM where low (<42% of calories) and high (45-50%) carbohydrate diets were compared. Those women on the low carbohydrate diet had lower postprandial glucose levels and reduced requirements for insulin therapy with significantly better perinatal outcomes. Conversely, it has also been found that by consuming low glycemic index foods, up to 60% of the total dietary energy can be given in the form of carbohydrates with no significant change in the glycemic response in healthy third trimester pregnancies (Fraser R, Ford F, & Lawrence G, 1988; Clapp J, 1998). A more recent study evaluating the impact of intensive management of GDM on maternal and fetal morbidity concluded that diets consisting of 55% of energy from carbohydrate were associated with decreased incidence of macrosomia suggesting that careful distribution of carbohydrates and low glycemic index foods may help limit postprandial hyperglycemia (Rømon M, Nuttens M, Vambergue A, Verier-Mine O, Biausque S, Lemaire C et al, 2001).

Restricting carbohydrate intake below 38% of total energy results in ketonuria (Javanovic-Perterson & Peterson, 1990). Subsequently, distribution of energy from protein and fat would be altered, in this case, which may contribute further to the development of Type 2 diabetes during the postpartum period. An increase in protein is appropriate during pregnancy especially in the third trimester when new fetal and maternal tissues are being synthesized at an increased rate (CDA, 1991). Moses, Shand and Tapsell (1997) assessed usual dietary intake in women with or without reoccurrence

of GDM and found that those women with reoccurrence of GDM had higher overall intakes of fat. Increasing fat intake beyond recommended levels of ≤35% of the total caloric intake to achieve glycemic control during gestation may be a cause for concern during the postpartum period as it 1) may promote weight gain during the postpartum period, and 2) sends a conflicting educational message to women who are already at a greater risk of developing diabetes during the postpartum period. Weight gain during the postpartum period has been found to be a contributing risk factor in the future development of Type 2 diabetes. Furthermore, the type of fat may also be important in the diets of women with or at risk of developing GDM. In a recent study, increased body weight and decreased polyunsaturated fat intake were found to be independent predictors of glucose intolerance in pregnant Chinese women diagnosed with IGT and GDM (Wang Y, Storlien L, Jenkins A, Tapsell L, Jin Y, Pan J et al, 2000). Energy intake from carbohydrate and fat remain controversial in the area of GDM. More research is needed in this area to optimize nutrition intake and its impact on glycemic control and pregnancy outcomes.

In nonpregnant individuals with diabetes, the type of carbohydrates in the diet has been explored in great detail, with considerable research in the areas of the glycemic index and dietary fibre. The terms simple and complex carbohydrates should no longer be used to rank carbohydrates, as they do not help to determine the impact of carbohydrates on blood glucose levels (FAO/WHO, 1998). Factors that can influence carbohydrate absorption rate and blood glucose levels can be predicted by more than chemical composition such as; food form, ingested particle size, starch structure and cooking method (CDA, 1998).

The glycemic index (GI) expresses the rise in blood glucose after consuming carbohydrate-rich food relative to a rise in blood glucose caused by an equal amount of a known standard (white bread or glucose) (Table 2) (CDA, 1998; Wolever, Jenkins, Jenkins, and Josse, 1991). The principle of the GI is based on reducing postprandial glucose responses by lowering the rate of carbohydrate absorption (Wolever, 1997). Therefore, the lower the glycemic index the lower the rise in blood glucose levels. In patients with diabetes, "studies suggest that replacing high-glycemic-index carbohydrates with low-glycemic-index forms will improve glycemic control and, among persons treated with insulin, will reduce hypoglycemic episodes (Willett, Manson, & Liu, 2002). It is further suggested that these changes can be made by replacing products made with white flour and potatoes with whole grain and minimally refined products. Thus, to meet the guidelines of Canada's Food Guide to Healthy Eating instruction should also include the substitution of low GI foods for high GI foods within "the same food group" (Laverdiere & Bell, 2003).

Table 2
Glycemic Index (GI) Values

Food Item	Glycemic Index Value (compared to glucose=100)
Bread, white	95
Honey	87
Puffed Rice Cake	82
Jelly Beans	80
Cereal, Cornflakes	80
Gatorade, sport drink	78
Coca Cola, soft drink	63
Cookie, Arrowroot	63
Baked Potato, skin	60
Banana	58
Orange Juice	53
Rice, white	51
Cereal, All-Bran	50
Macaroni, plain, boiled	45
Bread, 9 grain	43
Apple Juice	41
Baked Beans, canned	40
Orange, peeled	40
Green Peas, boiled	39
Apple, raw	34
Skim Milk	32
Yogurt, low fat, fruit (Aspartame)	14
Peanuts, plain	13

(Foster-Powell, Holt & Brand-Miller, 2002)

The use of the glycemic index may not be useful to every patient with diabetes due to concerns by some, that it may be too complicated to teach, it may limit food choices, and its application in mixed meals is unclear. However, more wide spread use of the GI is emerging and more teaching tools are being developed, including, the new GI tables of ~1300 foods making it easier to meet the guidelines of a healthy diet while consuming low GI foods (Powell, Holt & Brand-Miller, 2002). Evidence exists that people with Type 2 diabetes who were taught the GI as part of their nutrition therapy consumed higher intakes of carbohydrates and dietary fibre and consumed lower intakes

of fat while exhibiting low blood glucose and lipid levels compared to those who followed the advice of traditional nutrition therapy (Frost, Wilding, and Beecham, 1994). As previously mentioned, low glycemic index foods when used within a diet consisting of up to 60% carbohydrates of the total dietary energy resulted in no significant increase in the glycemic response of healthy pregnant women (Fraser R et al, 1988; Clapp J, 1998). Careful distribution of carbohydrates and low glycemic index carbohydrates may help limit postprandial hyperglycemia in women with GDM (Romon M et al, 2001). The use of the GI in a diabetic diet should complement the individualized meal plan in its goal to achieve good glycemic control (Canadian Diabetes Association, 1998). Given that GDM is often a temporary condition, its use during nutrition therapy may be limited to those individuals who are highly motivated, however these skills, may benefit this group of women over the longterm in the prevention of Type 2 Diabetes and cardiovascular disease.

Some beneficial effects of dietary fibre, which have been identified include improvements in constipation, delayed glucose absorption, decreased serum lipids, and weight control. Total fibre consists of the following two components: dietary fibre and functional fibre. "Dietary fibre consists of nondigestible carbohydrates and lignin that are intrinsic and intact in plants" whereas, "functional fibre consists of isolated, nondigestible carbohydrates that have beneficial physiological effects in humans" (Dietary Reference Intakes for Energy, Carbohydrates, Fibre, Fat, Protein and Amino Acids, 2002). Viscous fibres may delay gastric emptying therefore slowing the rate of absorption leading to the sensation of fullness, improve postprandial blood glucose concentration, interfering with the absorption of dietary fat and cholesterol, recirculation of enterohepatic cholesterol

and bile (Dietary Reference Intakes for Energy, Carbohydrates, Fibre, Fat, Protein and Amino Acids, 2002). Functional fibres are known to improve fecal bulk and aid in constipation. As discussed previously, many factors contribute to the absorption of carbohydrates, thus dietary fibre may be one dietary component that can be modified to slow the absorption of glucose. A synergistic relationship between glycemic load and dietary fibre was observed in the Health Professionals Follow-Up Study where diet and lifestyle factors in relation to chronic diseases were investigated (Salmeron et al, 1997). It was found that those individuals who consumed diets with high glycemic index foods and low cereal fibre were at increased risk of developing Type 2 diabetes. Much of the research surrounding dietary fibre has been carried out in patient groups with Type 2 diabetes; it is assumed that dietary fibre improves maternal glycemic control but it remains unknown whether dietary fibre improves pregnancy outcomes in women with GDM. The Canadian Diabetes Association recommends a total dietary fibre intake of at least 25-35 g/day, while including more foods and food combinations of cereal fibre and low glycemic index (Canadian Diabetes Association, 1998). More recently the Dietary Reference Intakes for Energy, Carbohydrates, Fat, Fibre, Protein and Amino Acids, 2002 suggest approximately 14 g/1000kcal/day of total fiber or 25 g of dietary fibre for non-pregnant women aged 19-50yrs/ 28 g of dietary fibre for pregnant women aged 14-50 yrs. In addition, dietary fibre may help to alleviate chronic constipation, which is most often present during pregnancy (Canadian Diabetes Association, 1991).

A common function to both the glycemic index and dietary fibre is limiting rapid glucose absorption. An additional approach to this concept is meal frequency, which refers to more frequent smaller meals that are spread out over a longer period during the

day, which may lead to decreased glucose absorption. Research in this area is limited, and as previously mentioned; recommendations related to meal frequency are often based largely on empirical evidence. It is not known whether increasing the meal frequency improves maternal blood glucose levels and pregnancy outcomes, however, in non-pregnant individuals with diabetes it has been shown to influence insulin secretion and glucose tolerance by decreasing the need for insulin (Jenkins et al, 1989). Both the Canadian and American Diabetes Associations indicate no specific recommendations regarding meal frequency, but encourage small frequent meals as this may reduce acute peak glycemic events in some individuals, and may reduce the incidence of nausea and heartburn most commonly reported during pregnancy (Canadian Diabetes Association, 1998; American Diabetes Association, 1998).

In summary, there is no 'one' diet for someone diagnosed with diabetes. The current recommendations outline the emphasis that is placed on the individualized meal plan where consideration should be given to the individuals eating habits and varying lifestyle factors. Nutrition recommendations such as, energy requirements, and appropriate intakes of macronutrients and micronutrients, are therefore largely dependent on metabolic parameters such as glycemic control and appropriate weight gain as they are the basis for ongoing modifications in nutrition therapy for women diagnosed with GDM. Since women with GDM are at increased risk for developing Type 2 diabetes later in life, emphasis should also be placed on healthy lifestyle behaviours, such as diet and exercise modifications, during the postpartum period. Long-term goals should include a diet rich in variety and dietary fibre and low in fat coupled with regular physical activity to help maintain a healthy weight. Both lifestyle factors, diet and physical activity, can be

modified to prevent weight gain during the postpartum period, which is a major risk factor in developing Type 2 Diabetes.

iii) Medication

There are two types of medication used for blood glucose control in the management of diabetes: oral hypoglycemic agents and insulin therapy. However, the use of oral hypoglycemics is not recommended during pregnancy (CDA, 1998). Older sulfonylureas, a type of oral hypoglycemic agent, cross the placenta due to their small molecular size. However, a study done by Langer, Conway, Berkus, Xenakis, and Gonzales (2000) using glyburide, a newer type of oral hypoglycemic agent with a larger molecular weight, showed that in the presence of fasting hyperglycemia, glyburide was safe and effective. The Canadian Diabetes Association recommends that if nutrition therapy does not result in the achievement of targeted glucose values, insulin therapy should be initiated (CDA, 1998), thereby reducing the exposure of the fetus to the hyperglycemic environment. McFarland, Langer, Conway, and Berkus (1999) found that those women with GDM whose fasting blood glucose levels were above 95 mg/dL (5.3 mmol/L) did not improve their glycemic control after the first week of dietary therapy, whereas those women with fasting values at or below 95 mg/dL (5.3 mmol/L) were more likely to achieve continued improvement in glycemic control after two weeks of dietary therapy. It was also found that those women requiring insulin therapy weighed more and were diagnosed with GDM at earlier gestational ages. The American Diabetes Association recommends that if nutrition therapy does not consistently maintain fasting and/or 2-hour postprandial blood glucose targets on two or more occasions within a one

or two week period, insulin therapy should be considered (ADA, 1998). This protocol is highly dependent on self-monitoring of blood glucose several times daily. Once insulin therapy is initiated, multiple daily injections (Nachum, Ben-Shlomo, Weiner, and Shalev, 1999) are advised where adjustments can be made based on glycemia results measured by self-blood glucose monitoring.

iv) Regular Physical Activity

One of the goals in the management of GDM, as mentioned previously, is achieving good glycemic control. In addition to nutrition therapy, regular physical activity can be safe and offer many short-term and long-term benefits to women with GDM (Horton, 1991). It is well known that exercise improves insulin sensitivity, and has blood glucose lowering effects in both non-diabetic and diabetic patients (Horton E, 1991). There is some controversy that exists in regards to the safety of exercise during pregnancy. It has been suggested that the safest form of exercise should not cause fetal distress, low infant birth weight or uterine contractions, and it should not produce maternal hypertension >140/90 mmHg (Jovanovic, 1998).

One study concluded that an upper-arm ergometer program (equipment used to isolate upper-arm muscle groups) was the most accepted and safest form of exercise where no maternal hypertension, fetal distress, or uterine contractions were observed in women with GDM (Jovanovic-Peterson and Peterson, 1991). Improved glycemic control was noted within a 4-week period in those women treated with diet plus exercise compared to those women treated with diet alone. It was also suggested that if optimal glycemic control was not achieved by diet alone, safe exercise could perhaps replace

insulin therapy. This was confirmed by Bung, Artal, Khodiguian, and Kjos (1991) where 17 women with GDM requiring insulin therapy enrolled in an exercise program and achieved good glycemic control, without initiating insulin therapy.

A more recent study concluded that postprandial exercise, such as very light walking (2.52 km in 1 hour, 9 beats per minute (bpm) increase in heart rate), decreased postprandial blood glucose levels in women with GDM. Researchers suggested that light postprandial exercise could potentially avoid or delay insulin therapy and could be applied in the clinical setting as simply avoiding rest in the postprandial period (Garcia-Patterson, Martin, Ubeda, Maria, De Leiva, and Corcoy, 2001). The benefits of regular physical activity in women with GDM are farther reaching than good glycemic control. The long-term benefits of such programs have the potential to play a role in the prevention of Type 2 diabetes in this high risk population.

v) Self-Monitoring of Blood Glucose and Glycemic Control

Self-monitoring of blood glucose (SMBG) is an essential component in achieving good glycemic control (CDA, 1998). SMBG allows the individual and the health care professional to make the necessary adjustments to diet, physical activity, or insulin therapies. Accurate record keeping of blood glucose measurements should be stressed to the individual with GDM.

Controversy remains in the area of frequency and timing of blood glucose measurements (Homko, Sivan, and Reece, 1998). When determining the frequency of testing, the benefits of monitoring and the cost and pain associated with SMBG should all be considered (CDA, 1998). Generally, women with GDM are encouraged to do SMBG

at least four times per day; before breakfast, and then either 1 hour or 2 hours after meals. Recently, Langer and Langer (1994) compared intensified SMBG of seven times per day using blood glucose monitors to a conventional group where weekly venous glucose measurements were supplemented by SMBG four times per day. It was found that those in the intensified group had a greater need for insulin therapy but had lower rates of macrosomia, caesarean section, and metabolic complications than those in the conventional group. It has also been found that postprandial glucose levels rather than premeal glucose levels were better determinants for insulin adjustments where the occurrence of fetal complications were reduced (De Veciana et al, 1995). Therefore, dietary management for GDM focuses on reducing postprandial glucose levels to reduce fetal exposure to hyperglycemia.

In a study examining the emotional adjustment to the diagnosis and intensified treatment of GDM, it was concluded that SMBG provides reassurance regarding glycemic control, which can enhance the patient's confidence and ability to cope with the management of their condition (Langer N & Langer O, 1994). SMBG enhances patient knowledge, facilitates lifestyle modifications, allows the individual to play an active role in their management of GDM, and appears to improve neonatal outcomes.

The target glucose values associated with the best neonatal outcomes in GDM are presented in Figure 3.

Figure 3
Target glucose values for GDM

Fasting blood glucose	<5.3 mmol/L
1 hour postprandial blood glucose	<7.8 mmol/L
2 hour postprandial blood glucose	<6.7 mmol/L

(CDA, 1998)

b) Postpartum Management

Postpartum care of women with GDM is directly related to the risk of developing Type 2 Diabetes later in life. Approximately half the women with GDM will develop Type 2 diabetes within 15 years postpartum (O'Sullivan, 1982; Zulaika & Alexis, 1990; Kjos et al, 1995; Steinhart et al, 1997). Because this population is at risk of developing Type 2 Diabetes, other risk factors such as cardiovascular disease should also be considered. In fact, it is well known that there is an association between diabetes and cardiovascular risk factors, which includes obesity, hypertension, dyslipidemia, hyperinsulinemia, insulin resistance, and arteriosclerosis (Reaven G, 1988;DeFronzo R & Ferrannini E, 1991). It has been hypothesized that insulin resistance may be the underlying cause of this cluster of factors. Metabolic studies have demonstrated insulin resistance in women who previously had GDM (Catalano P, Bernstein I, Wolfe R, Srikanta S, Tyzbir E, & Sims E, 1986; Ward W, Johnston C, Beard J, Baneditti T, Halter J, & Porte D, 1985). Therefore, women with GDM may be at increased risk of the development of cardiovascular risk factors such as hyperlipidemia as well as Type 2 Diabetes.

It is currently recommended that women with GDM be advised to achieve a healthy body weight and exercise regularly postpartum to reduce this risk of Type 2 diabetes (Canadian Diabetes Association, 1998). In addition, it is suggested that this population be tested for the presence of glucose intolerance or diabetes between 6 weeks to 6 months postpartum using the 75g, 2-h OGTT.

As discussed previously, there are several factors that are predictive of Type 2 diabetes in women with GDM such as increased prepregnancy BMI, the severity of glucose intolerance during pregnancy, and the presence of high glucose values on postpartum OGTT (Dornhorst & Rossi, 1998). More specifically, the degree of obesity in the postpartum period is a major determinant of the impairment of subsequent insulin sensitivity (O'Sulivan, 1982). Thus, postpartum weight control would appear to be the most plausible modifiable risk factor in preventing Type 2 diabetes in the postpartum period.

Women with GDM represent a population who have the opportunity to prevent GDM in subsequent pregnancies and the later onset of Type 2 diabetes. In addition to the above mentioned risk factors, there are other modifiable risk factors in the prevention of Type 2 diabetes. Those modifiable risk factors include postpartum weight gain, dietary factors and physical inactivity. It is well known that obesity is associated with insulin resistance and that weight loss improves insulin sensitivity and glycemic control in patients with Type 2 diabetes (Ludvik, Nolan, Baloga, Sacks, & Olefsky, 1995). O'Sullivan (1982) showed that 47% of the women with a history of GDM who were obese or gained weight postpartum developed glucose intolerance within 16 years compared to 28% of the women who were not obese or who had lost weight postpartum.

Long et al (1994) demonstrated that weight loss in severely obese individuals with IGT prevented the progression to diabetes by >30 fold compared to the control group.

Studies have also shown that it is possible to reduce the risk of Type 2 diabetes with diet and physical activity. Both are known to improve glucose tolerance and insulin resistance through weight control. Recently results from the Nurses' Health Study where 84,941 female nurses between the ages of 30-55 were followed for sixteen years indicated that obesity, lack of physical activity, and a poor diet (low fibre/high fat) were associated with significantly increased risk of diabetes (Hu et al, 2001). Tuomilehto et al (2001) demonstrated that it is possible to prevent Type 2 diabetes in those people who are at high risk by providing long-term follow up and individualized counselling focused on weight reduction through lifestyle modification. Weight reduction was achieved by reducing total fat intakes, increased fibre intakes, and increased physical activity which resulted in a 58% reduced incidence of diabetes. Two other studies in Sweden and China made similar conclusions that changes in lifestyle are effective in preventing diabetes (Eriksson & Lingarde, 1991; Pan XR et al, 1997).

More recently, a study completed by the Diabetes Prevention Program Research Group (2002) demonstrated that intensive lifestyle intervention targeted at high risk groups reduced the incidence of diabetes by 58% as compared to the placebo group. Of the 3234 participants within this study who were followed for 2.8 years, 67% were female and 353 (16.1%) participants had histories of GDM. The lifestyle intervention group received 16 weeks of one-to-one counselling that was designed to meet a minimum of 150 minutes of moderate physical activity (i.e. brisk walking) per week and healthy low calorie diets low in fat as recommended by the Food Guide Pyramid (U.S.

Department of Agriculture, 2000). Lifestyle intervention was also found to be more effective than metformin, however, the incidence of diabetes in this group was reduced by 31% compared to the placebo group.

4. Summary of Literature

Gestational Diabetes Mellitus may result in many short-term and long-term complications for both the fetus and the mother. The maternal risk of developing Type 2 diabetes is of particular concern within this population. Research has shown that adopting healthy lifestyle behaviors can reduce the risk of developing Type 2 diabetes.

The management of gestational diabetes mellitus currently emphasizes the importance of healthy lifestyle behaviors and the continued maintenance of these changes throughout the postpartum period should be encouraged for the prevention of Type 2 diabetes. It is not well established to date whether the nutrition education received throughout pregnancy of women with gestational diabetes mellitus is sustained during the postpartum period. This study will further evaluate whether education on key nutritional modifications obtained upon diagnosis are maintained into the postpartum period in women with gestational diabetes mellitus.

Chapter Three:
Experimental Design & Methodology

A. Experimental Design

This study was conducted at the Royal Alexandra Hospital, the Grey Nuns Hospital, and the Northern Alberta Clinical Trials Research Centre, Edmonton, Alberta, Canada. It was a longitudinal pre-test/post-test design whereby the intervention group served as its own control. Participants were women with newly diagnosed GDM or IGT during pregnancy. Upon diagnosis of GDM or IGT during pregnancy, women were referred to area hospitals where they were screened and recruited for this study. Measurements were taken prior to the nutrition assessment at the initial referral appointment (herein stated as baseline time point), 2 to 3 weeks after receiving nutrition education (herein stated as the 2 weeks post-intervention), and at 6 weeks and 6 months postpartum. Variables measured included dietary intake, physical activity, postpartum weight control and biochemical risk factors for diabetes. Ethical approval for this study was received from the Health Research Ethics Board of the University of Alberta (Appendix B).

1. Screening Component

When this study was designed, the sample size was calculated to recruit 100 women with GDM. It should be noted; that due to various recruitment difficulties this study became a case series pilot study where baseline data obtained from study participants was used as a control.

a. Participants

To be eligible to participate in the study, women with GDM had to meet criteria based on the diagnosis of GDM, their age, type of and age of gestation and their willingness to comply with and understand the requirements of the study. Initially only those women diagnosed with GDM were recruited where GDM was assessed by either the 1-hour 50 g glucose load test taken at any time during the day or the 2-hour OGTT using the 75 g glucose load (two abnormal values as shown in Figure 1, Page 13). To increase enrolment, those women diagnosed with IGT during pregnancy (where one value on the OGTT was found to be abnormal as shown in Figure 1), were also recruited into the study, provided they received the same treatment protocol as those women with GDM.

The second selection criterion was related to age. Only those women between 19 and 39 years of age were selected. In some cases, the upper age limit was increased to 45 years of age to increase enrolment. Each case was assessed individually.

The third selection criterion referred to the type and age of gestation. Only those women with singleton pregnancies were eligible. In addition, it was required that the participants be enrolled by 32 weeks gestation to allow enough time for treatment intervention and follow up appointments.

The final selection criterion involved the participants' willingness to comply with and understand the requirements of the study. Each participant was contacted by phone and in person where they were explained the details, risks and benefits of the study and allowed the opportunity to read an information sheet. The participant was then asked to sign a consent form confirming they understood the details of the study. Each participant

was informed that participating in the study was voluntary and they could withdraw at any time.

Participants were excluded from the study if they had a previous diagnosis of GDM, IGT, diabetes mellitus, a current medical condition which altered their dietary practices or limited physical activity, if they became pregnant during the postpartum period, or if they were participating in another research study.

b. Recruitment

Recruitment began in September 2000 and ended in December 2001. Volunteers for the study were screened and recruited through referrals to both the Royal Alexandra Hospital Diabetes Clinic and the Grey Nuns Hospital Diabetes Clinic (Edmonton, Alberta). Recruitment methods included contacting and attending both area hospital gestational diabetes programs on a weekly basis to screen patient charts for selection criteria. The GDM clinic at the Royal Alexandra Hospital took place on Monday afternoons, Thursday mornings, and Friday mornings and the Grey Nuns Hospital GDM clinic took place on Wednesday mornings.

c. Procedures

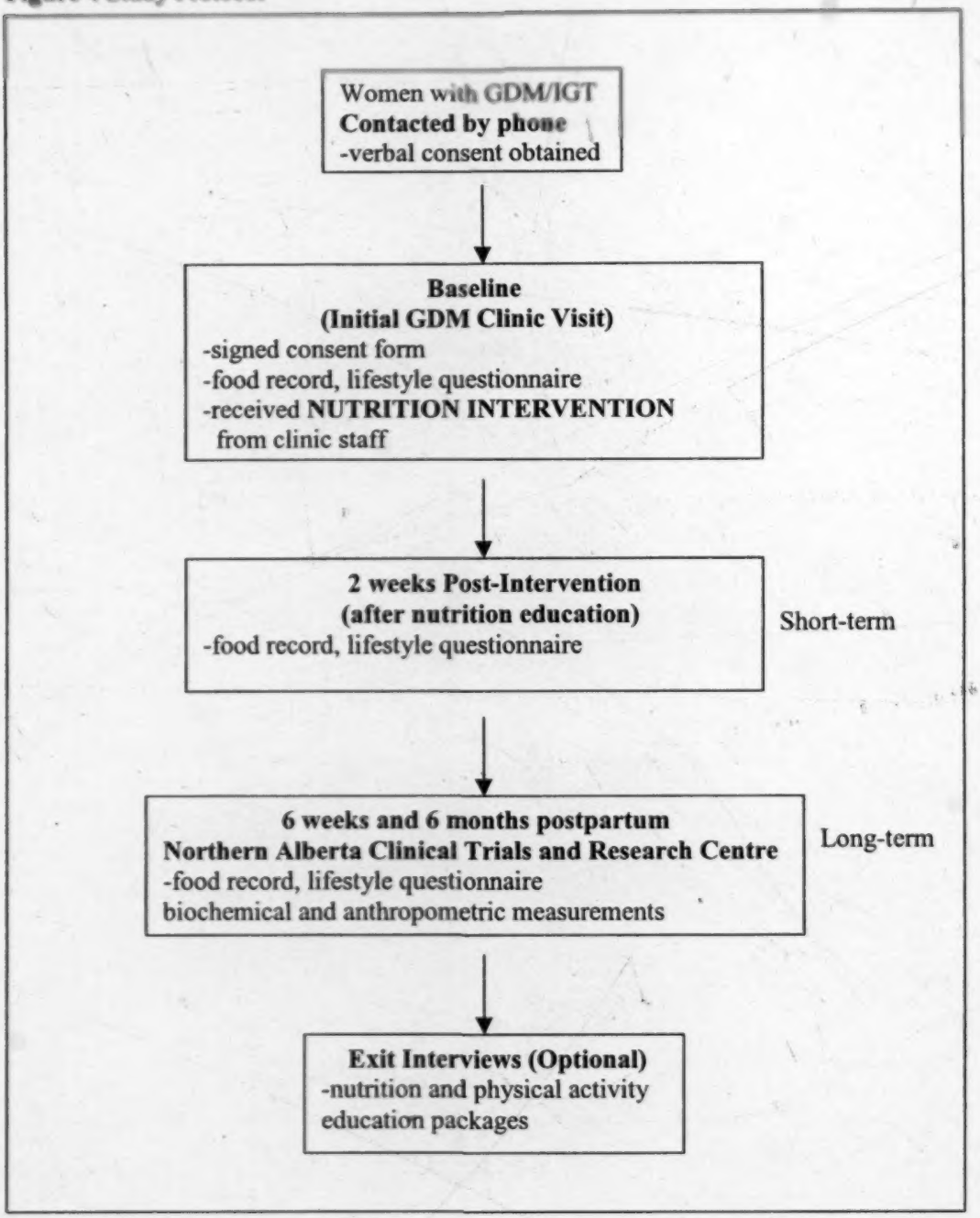
Once the patient was screened they were contacted by telephone. The study was then verbally explained to the patient. If the patient agreed to and understood the terms of the study they were asked to complete a 4–day food record and take it with them to their first clinic appointment where they would meet with the researcher. The researcher would meet with the patient fifteen minutes prior to their clinic appointment and reviewed an

information sheet and a consent form (Appendix C and D). Upon completion of the signed consent form, the 4-day food record was reviewed and a lifestyle questionnaire completed (Appendix E and F). The patient was then taken back to the waiting room where they would continue the gestational diabetes program.

2. Study Protocol

Participants were contacted/ seen at five time points throughout the study where 4-day food records, lifestyle questionnaires, biochemical and anthropometric measurements were taken as outlined in Figure 4.

Figure 4 Study Protocol



3. Intervention Component

The intervention component during the index pregnancy was carried out by on-site Diabetes Clinic Registered Dietitians (RD) trained in the area of Gestational Diabetes Mellitus as part of standard practice. Once all study criteria were met and signed consent was obtained, each study participant received nutrition education provided by the clinic RD, where their diet history was initially assessed during an individual interview session. Thereafter an appropriate meal plan was calculated and prescribed to the study participant. Nutrition education then took place in a group setting where the following main nutrition topics were discussed; how to follow a prescribed meal plan, meal frequency i.e. 3 meals/3 snacks, the role of carbohydrates in diabetes, the use of artificial sweeteners, increasing fibre intake, decreasing fat intake, increased consumption of milk, moderate consumption of fruit juice, and appropriate weight gain. All participants were given a Good Health Eating Guide Poster Pin-Up (CDA) handout where they could refer to their prescribed meal plan. Other areas of discussion included the role of lifestyle habits such as diet, exercise, and weight control in the management of diabetes. They were also informed about lifestyle modifications through diet and exercise as a way to potentially prevent or delay the onset of Type 2 Diabetes later in life.

Study participants were monitored weekly by the clinic RD for weight fluctuations and necessary dietary changes based on self-monitoring of blood glucose (SMBG), clinic fasting blood glucose levels, and diet tolerance. Study participants diagnosed with either GDM or IGT were treated uniformly as described above by professional staff working independently from the researcher.

B. Methodology

1. Dependent Measures

a. Dietary Intake

There are many ways to assess dietary intake; diet histories, food frequency questionnaires, diet recalls, and food records, all of which have their advantages and limitations. In this study, the dietary assessment method of choice was that of food records. Food records provide a measure of current intake that does not rely on memory. The study participant is instructed to record food and beverage items as they are consumed. However, record keeping does put some of the burden on the study participant and a certain level of literacy is required. Accuracy may decrease as the number of days increases and subjects may alter their diets according to their perception of acceptable dietary intake (Block, 1982).

Young et al (1953) demonstrated that for dietary assessment a 7-day record was consistent with the results of a 28-day recording period. Others found that 4-day food records retained approximately 90% of the information found in a 7-day food record (Cellier & Hankin, 1963) and that record keeping tends to deteriorate after the fourth day (Block, 1982). Therefore, the 4-day food record method was chosen as an estimate of current food intake for this group of study participants.

i. Procedures

Study participants were instructed at each time point how to record their food and beverage intake for 4 consecutive days, which included at least one weekend day. A sample of the food record diary can be found in Appendix E. Specific instructions were

given regarding the description of the food or beverage items, their measurements, and the importance of recording as close to the time of consumption as possible (Appendix G).

Dietary intake was assessed at 4 time points; baseline, 2 weeks post-intervention, 6 weeks and 6 months postpartum. Once food records were completed, they were reviewed by the researcher for accuracy in the presence of the study participant.

ii. Analysis

The 4-day food records were analyzed using the Food Processor Nutrient Analysis Software Version 7.50 (*esha* RESEARCH®, Salem, OR). Intake data from the 4-day food records was entered into this program where specific nutrient groups were selected for further analysis and comparison. All entries were verified for accuracy by comparing data entered into the software program to that recorded on the original food record. Mean daily intakes were calculated for energy, carbohydrate, dietary fibre, protein, fat, saturated fat, monounsaturated fat, and polyunsaturated fat. In addition, select micronutrients were analyzed including: Vitamin D, folate, calcium, and iron. Mean daily meal frequency and the number of servings from each of the four food groups of Canada's Food Guide were also assessed.

A measure of the overall quality of the diet was assessed using the Healthy Eating Index (HEI) developed by the USDA (Kennedy, Ohls, Carlson, & Flemming, 1995). The HEI uses scores for consumption of the suggested number of servings from each food group in the US Food Pyramid and the level of intake of fat, saturated fat, cholesterol and sodium as well as a score for dietary variety. The HEI is a "single summary measure of

diet quality that can be used to monitor changes in consumption patterns as well as serve as a useful tool for nutrition education and health promotion" (Kennedy et al, 1995). The HEI identifies the overall quality of the diet through the identification of 10 components. Each component has a maximum score of 10 and a minimum score of zero where scores are rated as provided in Table 3. A total score is calculated and assessed based on a maximum score of 100. "An HEI score over 80 implies a 'good' diet, an HEI score between 51 and 80 implies a diet that 'needs improvement', and an HEI score of less than 51 implies a 'poor diet'" (Bowman S, Lino M, Gerrior S, Basiotis P, 1994-96).

Table 3
Healthy Eating Index Scoring System based on 2200 Kcal/day

Components	**Maximum Score of 10**	**Criteria for Minimum of 0**
1. Grain Consumption[1]	9	0
2. Vegetable Consumption	4	0
3. Fruit Consumption	3	0
4. Milk Consumption	2	0
5. Meat Consumption	2.4	0
6. Total Fat Intake	≤30% or less energy from fat	≥45% or more energy from fat
7. Saturated Fat Intake	<10% energy from saturated fat	≥15% or more energy from saturated fat
8. Cholesterol Intake	≤300 mg or less	≥450 mg or more
9. Sodium Intake	≤2400 mg or less	≥4800 mg or more
10. Food Variety	≥8 or more different items over a four day period	≤3 or fewer different items over a four day period

[1]Scores of components 1 through 5 are calculated based on serving size in the US Food Guide Pyramid.
(Bowman et al, 1994-1996)

For the food groups, individuals with an intake at the recommended level receive a perfect score of 10 while a score of zero is given if no foods from a particular group are eaten. The recommended number of servings depends on the individual's caloric requirement. Individual caloric requirements for this study were based on a 2200

Kcal/day diet. Intermediate scores for all components are calculated proportionately. Previously documented modification to the USDA procedure was made to the variety component, where a score of ten was allocated if ≥24 items were identified over a three day period, rather than ≥16 items over a 3 day period (Hann CS, Rock CL, King I, & Drewnowski A, 2001). Similarly in this study, the variety component was modified to reflect a four day food record where a score of 10 was allocated when ≥32 items were identified over a four day period and a score of zero when ≤12 items were identified. All intermediate scores were then calculated proportionately.

b. Postpartum Weight Management and Body Composition

Weight management was assessed during the postpartum period using weight, height, and BMI. For descriptive purposes, body composition was also assessed using waist circumference and percent body fat (%BF). Weight was measured using a standard balance beam scale. The study participant was instructed to wear light weight clothing when possible and was asked to remove their footwear. Weight was recorded in kg to the nearest 0.1 kg. Height was measured using a stadiometer where the participant was measured without footwear. The study participant was instructed to stand erect, arms hanging by their sides, looking straight ahead. Measurements were recorded in cm to the nearest 0.1 cm. BMI was subsequently calculated (kg/m^2).

Recent studies have shown that measuring waist circumference within various BMI categories helps to identify those at increased risk, particularly women already at increased risk because of elevated BMI, of developing hypertension, type 2 diabetes mellitus, dislipidemia, and the metabolic syndrome (Janssen I, Katzmarzyk P & Ross R,

2002; Ardern C, Katzmarzyk P, Janssen I & Ross R, 2003). Furthermore, waist circumference and BMI have been found to independently contribute to the prediction of non-abdominal, abdominal subcutaneous, and visceral fat in white women and men. (Janssen I, Heymsfield S, Allison D, Kotler D & Ross R, 2002). Waist circumference was measured according to the method of Larsson et al (1984). Study participants were measured after a night of fasting and were instructed to stand erect with their abdomen relaxed with their arms at their sides. The lowest rib margin was located, as was the iliac crest, and the elastic tape was applied firmly and horizontally midway between these two points while the measurement was taken to the nearest millimetre. At the time of the measurement the study participant was asked to breathe out gently as to prevent them from contracting their muscles or from holding their breath.

Body fat was assessed at both the 6 weeks and 6 month post partum time points using the bioelectrical impedance method (BIA) on the Tanita TBF-300P foot to foot body composition analyzer (QuickMedical®, Snoqualine, WA). This is a reasonably accurate and very quick method to measure body fat (Utter, Nieman, Ward, and Butterworth, 1999; Nunez et al, 1997). Study participants were measured during a fasting state and were asked to remove their footwear to ensure proper foot contact with the four electrode foot pads. They were instructed to stand evenly on the foot pads in a relaxed state. This procedure was repeated three times with measurement recorded to the nearest 0.1% BF.

c. Measurement to determine risk of diabetes

i. Plasma glucose (OGTT)

After an overnight fast, study participants reported to the research centre where a fasting blood sample was taken. They were then asked to consume a drink containing 75 g of glucose within a five minute time period and a second blood sample was then taken at 2 hours. This test was performed during the post partum period at both 6 weeks and at 6 months.

Blood samples were then centrifuged and sent for analysis by Dynacare Kasper Medical Laboratory, Edmonton, AB. Plasma glucose was analyzed using the hexokinase Method on the Roche Diagnostics-Hitachi 917, Gluco-quant glucose reagent kit insert.

ii. Serum insulin, fasting and 2-hour

The blood samples taken for the serum insulin were collected simultaneously with those of the plasma glucose, a fasting and 2-hour sample. Serum insulin was also analyzed by Dynacare Kasper Medical Laboratory where the Immunological Sandwich Technique, Antigen Antibody Reaction method was used with the Roche Diagnostics Elecsys 2010 System Elecsys Insulin Reagent Kit Catalogue # 2000-04-217911301 01 01.

iii. Lipid profile

An additional tube of blood was collected for the assessment of fasting plasma lipids where total cholesterol (TC), high density lipoproteins-cholesterol (HDL-C), low density lipoproteins-cholesterol (LDL-C), and triglycerides (TG) levels were analyzed. TC levels were analyzed by cholesterol oxidase using the Spectrophotometric Method,

HiCo Cholesterol Roche Diagnostics Package Insert. HDL-C cholesterol levels were analyzed by Homogenous Enzymatic Colorimetric Test, Hitachi HDL-C Plus Second Generation Reagent Package Insert #2000-01-1963953001 01 05. The LDL-C cholesterol levels were analyzed using the calculated method i.e. TC (mmol/L) – HDL-C (mmol/L) – (TG (mmol/L) / 2.2). The TG levels were analyzed by glycerol blanking using the Spectrophotometric Method, Roche Hitachi TG Reagent Package Insert.

d. Physical Activity

Physical activity data was collected, for descriptive purposes only, using lifestyle questionnaires presented in Appendix H (please note lifestyle questionnaires differed slightly at all four time points throughout the study to reflect pregnancy and postpartum lifestyle issues). Due to time restraints, questions were limited to frequency, duration and intensity in the above mentioned questionnaires where only scheduled daily activity was reviewed and considered by the researcher. Scheduled daily activity was assessed using the Compendium of Physical Activity: Classification of energy costs of human physical activities where total caloric expenditure was reported per week. (Ainsworth, Haskell, Leon, Jacobs, Montoye, Sallis et al, 1993; Ainsworth et al, 2000). Therefore, Frequency x Duration x Intensity x Body Weight = Energy Expended (Kcal/week) via scheduled daily activity.

C. Statistical Analysis of Results

Statistical analysis was performed using the Statistical Package for the Social Sciences Version 11.0 (SPSS Inc., Chicago, IL). Dietary data were entered into the SPSS

files from a spreadsheet in the Food Processor Nutrient Analysis Software Program Version 7.5. To verify accuracy, all entries were verified by comparing the recorded data to a printed copy of the data files from the Food Processor Nutrient Analysis Software Program. All other data were entered into SPSS files from a spreadsheet in Microsoft Excel, again where, all entries were verified by comparing the recorded data to a printed copy of the data files entered into Microsoft Excel.

All results are presented as mean ± the standard deviation (SD). Sphericity test normal distribution was assessed prior to each repeated measures analysis using the Mauchly's Test of Sphericity. When sphericity was not achieved, the Huynh-Feldt adjusted p-values were reported. All significant p-values ($P<0.05$ or $P<0.01$) are indicated by either bold print or otherwise noted on specific tables.

All dietary intakes were analyzed based on Within-Subject Design using Repeated Measures. This method is appropriate for measuring sets of data where each subject is present in all treatment conditions thus resulting in no between group differences (Keppel and Zedeck, 1989). All variables were analyzed by general linear model repeated measures using the Statistical Package for the Social Sciences Version 11.0 (SPSS Inc., Chicago, IL). Post Hoc multiple comparison tests are not appropriate where there are no between-subject factors such as in this study design. To investigate whether dietary modifications were achieved and maintained throughout the postpartum period paired t-tests were used to determine at what specific time point changes might have occurred. In order to minimize type 1 error using paired t-tests and increase the level of confidence of the results, the alpha is set at $p<0.01$ providing a type 1 error of only 0.058 (5.8%) rather than a type 1 error of 0.265 (26.5%) using an alpha of $p<0.05$ (Keppel and Zedeck,

1989)(Appendix I). Therefore, $p<0.01$ will be used for the analysis of all dietary variables using paired t-tests.

1. Dependent Measures

Nutrients analyzed consisted of: calories, protein, carbohydrates, fat, saturated fat, polyunsaturated fat, monounsaturated fat, cholesterol, total dietary fibre, vitamin D, folate, calcium, and iron. Diet quality variables consisted of: the four food groups outlined by the Canada's Food Guide to Healthy Eating, Healthy Eating Index (HEI), and meal frequency. All variables were measured at baseline, 2 weeks post-intervention, 6 weeks and 6 months postpartum.

Weight management (weight, BMI, and waist circumference) were all compared to self reported prepregnancy measurements and/or normal values. Percent body fat was also compared to healthy adult standards (Lohman et al, 1997).

To determine the presence of risk factors for diabetes, fasting serum glucose, serum insulin, and serum lipids were measured at both 6 weeks and 6 months postpartum. These results were reported as mean ± standard deviation and were compared to normal adult ranges (University of Alberta Hospitals, 1994).

Chapter Four:
Results

A. Participant Recruitment

Approximately 106 women were screened based on the study criteria after being referred to the Royal Alexandra and Grey Nuns Hospital Diabetes Clinics. Twenty-four of those did not meet study criteria; twenty-three declined participation due to either time constraints or travel to and from additional postpartum appointments; thirty were unavailable for telephone contact; and twenty-nine were enrolled into the study. This represents a 16% enrolment rate. Almost one half (49%) of the women screened were contacted by phone. To improve enrolment, the upper age limit was increased from 39 to 45 years of age. As well, women diagnosed with IGT during pregnancy were accepted into the study provided they received the same treatment interventions as those women diagnosed with GDM currently enrolled in the study.

Of the twenty-nine study participants, eleven completed the required measurements (baseline, 2 weeks post-intervention, 6 weeks, and 6 months postpartum); however, ten participants withdrew from the study prior to completing 6 weeks and 6 months postpartum measurements due to time constraints or missed appointments. The remaining eight enrolled participants either demonstrated abnormal lab values during postpartum visits, or developed conditions such as IGT, Type 2 Diabetes, or high cholesterol levels and they were withdrawn from the study by researchers and referred to their family physician. Of these eight, one participant became pregnant, another was diagnosed with Type 2 diabetes and received treatment from her family physician, two participants were diagnosed with high cholesterol

levels, two were diagnosed with high cholesterol in combination with IGT, and two were diagnosed with IGT. In view of the above, there were two distinct groups; those women who completed study measurements up to and including 6 month postpartum visit (n=11), and those women who completed study measurements up to and including 6 weeks postpartum (n=8). Having too small a sample size for analysis was a concern, and as a result, the study design was altered to reflect a case study series. Case study series is appropriate for detailed analysis and examination of a small number of subjects where there is no requirement that the subjects studied be compared with any other subjects or groups (Keppel and Zedeck, 1989).

Table 4 & 5 represents summaries of self-reported demographics, anthropometric information, supplement intake, insulin requirements, and breastfeeding duration. Of the 19 women who completed the study up to and including the 6 week postpartum measurements, 14 were of Caucasian descent, 3 were of Phillipino descent, and 2 were of Asian descent.

Table 4
General Characteristics of Study Participants

Variable	Study Participants (n=19)
Age (yr)	29.8 ± 5.4[1]
Height (cm)	160.7 ± 6.7
Prepregnancy Weight (kg)	73.8 ± 21.5
Prepregnancy BMI (kg/m^2)	28.5 ± 7.3[2]
Age of GMD/ IGT Onset (weeks of gestation)	28.0 ± 2.6
Infant Birth Weight (g)	3500.3 ± 481.7
Insulin Requirement During Pregnancy	34.5%
Use of a Prenatal Multivitamin	89.5%
Folic Acid Supplement	10.5%[3]
Breast Feeding at 6 weeks	84.2%
Breast Feeding at 6 months	50.0%[4]

[1] Results presented as mean ±standard deviation.
[2] BMI based on self-reported prepregnancy weight.
[3] Folic Acid supplement was taken either alone or in conjunction with a prenatal Multivitamin supplement which also contained folic acid.
[4] Results based on group n=11

Table 5
Personal Characteristics and Insulin Requirements of Study Participants

Variables	Study Participants (n=19)
Post Secondary Education	44.8%[1]
Children at Home	36.8%
Family History of Diabetes	51.7%
Smokers	20.6%[2]

[1] Results presented as percentage (%).
[2] Includes those study participants who smoked during pregnancy.

B. Dependent Measures

1. Main Results

The main results include comparisons between four assessment points, baseline, 2 weeks post-intervention visit, 6 weeks postpartum, and 6 months postpartum.

a. Dietary Intake

Table 6 shows dietary intakes (mean ± standard deviation) of calories, carbohydrates, total fat, polyunsaturated fat, monounsaturated fat, saturated fat, protein, and total dietary fibre at each of the four assessment points, baseline, 2 weeks post-intervention, 6 weeks postpartum, and 6 months postpartum. Significant differences were found for protein and fibre intakes. Dietary intake of protein increased significantly ($p=0.01$) between baseline and 2 weeks post-intervention and returned to baseline values at 6 weeks postpartum ($p<0.001$) and remained low through to the 6 month postpartum measurement. Total fibre intake increased significantly ($p=0.002$) between baseline data and 2 weeks post-intervention and returned to baseline values at 6 weeks postpartum ($p<0.001$) and remained low at 6 months postpartum measurement. No significant differences in intake were found for the following variables: calories, carbohydrates, total fat, polyunsaturated fat, monounsaturated fat, and saturated fat.

Table 6
Dietary Intake of Calories, Macronutrients, and Fibre.

Variable	Baseline data (n=19)	2 weeks Post-Intervention (n=19)	6 wks Postpartum (n=19)	6 months Postpartum (n=11)	P value
Calories (Kcal)	2004 ± 434 [1]	2117 ± 486	1977 ± 467	2033 ± 587	0.199 [2]
Carbohydrates (g)	264 ± 47	272 ± 56	257 ± 73	263 ± 78	0.662
Protein (g)	80 ± 16 [a]	101 ± 23 [b]	78 ± 19 [a]	76 ± 23 [a]	<0.001
Total Fat (g)	72 ± 29	75 ± 28	74 ± 22	76 ± 27	0.426
Polyunsaturated Fat (g)	11 ± 6	10 ± 4	10 ± 5	10 ± 6	0.925
Monounsaturated Fat (g)	21 ± 8	22 ± 10	20 ± 9	22 ± 10	0.594
Saturated Fat (g)	24 ± 11	25 ± 11	25 ± 9	23 ± 9	0.254
Total Dietary Fibre (g)	17 ± 6 [a]	25 ± 6 [b]	17 ± 6 [a]	17 ± 4 [a]	0.001

[1] Results presented as mean ±standard deviation
[2] $p<0.05$ indicates change at any time point using General Linear Repeated Measures Test
[a,b] Indicate statistical significance of change between assessment points, using paired T-tests ($p<0.01$) to determine where significant changes occurred between assessment points.

Table 7 represents intake of macronutrients as a percentage (%) of the total energy consumed and total dietary fibre compared to the Dietary Reference Intakes (DRIs), 2002. Carbohydrate, protein and fat intakes (% energy) at all assessment points met the DRIs. Protein intake (per kg body weight (g/kg)) at three assessment points met the recommended levels except for the first measurement at baseline. Although there was a significant increase in the total dietary fibre intakes 2 weeks post-intervention, mean total dietary fibre intakes did not meet the DRIs at any of the assessment points.

Table 7
Dietary Intake of Macronutrients and Fibre Compared to the Dietary Reference Intakes (DRI)

Variable	Baseline Data (n=19)	2 weeks Post-Intervention (n=19)	6 wks Post-Partum (n=19)	6 months Post-Partum (n=11)	Recommended Intake	
					Adult	Pregnancy
Carbohydrates (%Kcal)	54[1] ± 7	52 ± 7	52 ± 7	52 ± 7	45 to 65%	45 to 65%
Protein (%Kcal)	16 ± 2	19 ± 3	16 ± 2	15 ± 3	10 to 35%	N/A
Protein (g/kg)	1.0[2] ±0.2	1.3 ± 0.4	1.0 ± 0.3	1.1 ± 0.4	0.80 g/kg/d	1.1g/kg/d
Total Fat (%Kcal)	31 ± 7	31 ± 6	33 ± 7	33 ± 6	20 to 35%	20 to 35%
Total Dietary Fibre (g/day)	17 ± 6	25 ± 6	17 ± 6	17 ± 4	25 g/day or 14g/1000 Kcal	28 g/day or 14g/1000 Kcal

(Dietary Reference Intakes, 2002)
[1] Results presented as mean percentage ± standard deviation
[2] g/kg body weight/day

Table 8 presents intakes (mean ± standard deviation) of the following selected micronutrients: Vitamin D, folate, calcium, and iron at each of the four assessment points. Significant differences between assessment points were found for Vitamin D. Although vitamin D did not increase significantly between baseline and 2 weeks post-intervention, intakes were significantly lower at 6 months postpartum compared to all other assessment points ($p=0.002$ between baseline and 6 months, $p=0.000$ between 2 weeks post-intervention and 6 months postpartum, and $p=0.002$ between 6 weeks postpartum and 6 months postpartum). Folate intakes were not significantly different between assessment points, however, a trend was observed ($p=0.054$). It was found that folate intakes tended to increase between baseline and 2 weeks post-intervention where it remained high until the 6 month assessment point.

Calcium values were found to be different between assessment points. Although mean calcium intake did not increase significantly between baseline values and 2 weeks post-intervention, they did decrease significantly between 2 post-intervention and 6 weeks postpartum assessments points ($p<0.001$). Calcium intake decreased further at 6 months postpartum compared to baseline ($p=0.001$) and 2 weeks post-intervention ($p<0.001$). No significant differences were observed between assessment points for iron intakes.

Table 8
Dietary Intake of Select Micronutrients.

Variable	Baseline data Prior to Intervention n=19	2 weeks Post-Intervention n=19	6 wks Postpartum n=19	6 months Postpartum n=11	P value
Vitamin D (mcg)	5 ± 3 [a,1]	7 ± 4 [a]	4.5 ± 2 [a]	3 ± 2.5 [b]	<0.001 [2]
Folate (mcg)	255 ± 104	316 ± 92	281 ± 106	250 ± 129	0.054
Calcium (mg)	1041 ± 369 [a]	1349 ± 467 [a]	917 ± 295 [b]	764 ± 363 [b,c]	0.000
Iron (mg)	14 ± 3 [2]	16 ± 4.5	14 ± 6	13 ± 5	0.327

[1] Results presented as mean percentage ± standard deviation
[2] $p<0.05$ indicates change at any time point using General Linear Repeated Measures Test
[a,b,c] Indicate statistical significance of change between assessment points, using paired T-tests ($p<0.01$).

Mean intakes of vitamin D did not meet the Recommended Dietary Allowances (RDA) as shown in Table 8 & 9 at the baseline assessment, however, after the intervention adequate mean intake of vitamin D was achieved. At the 6 weeks postpartum and 6 month postpartum assessments the RDA was not met for vitamin D. Mean calcium intake met the RDA at baseline and after intervention, but not at 6 weeks or 6 months

postpartum. Mean intakes of both folate and iron did not meet the RDA at any of the four assessment points. Table 9 represents number of study participants who did meet Recommended Dietary Allowances (RDA) of select micronutrients.

Table 9
Number of Study Participants Who Did Meet Recommended Dietary Allowances (RDA) of Select Micronutrients (excluding vitamin supplementation).

Variable	**Baseline data Prior to Intervention** (n=19)	**2 weeks Post-Intervention** (n=19)	**6 wks Postpartum** (n=19)	**6 months Postpartum** (n=11)	**RDA** Adult	Pregnancy
Vitamin D (μg)	8	13	8	3	**5**[1]	**5**[1]
Folate (μg)	2	4	2	1	**400**	**600**
Calcium (mg)	5	13	6	2	**1000**	**1000**
Iron (mg)	3	4	2	1	**18**	**27**

(Dietary Reference Intakes, 2001)
[1] Represents Adequate Intake (AI) recommendations where RDA cannot be determined.
* Individual intakes for micronutrients were compared to recommended dietary allowances
(RDA) throughout this study rather than mean intakes compared to estimated average intakes
(EAR) as this study reflects a case study series.

Table 10 represents daily meal frequency, number of servings of food from the four food groups, and Healthy Eating Index (HEI) scores (mean ± standard deviation) to assess overall diet quality at each of the four assessment points. There were significant differences found for meal frequency, vegetable and fruit intake, and milk and milk product intake. Daily meal frequency increased significantly between baseline and 2 weeks post-intervention ($p<0.001$) and decreased back to baseline values after 6 weeks postpartum ($p<0.001$) and remained low at 6 months postpartum ($p<0.001$). Intake of

vegetables and fruit decreased significantly between 2 weeks post-intervention and 6 weeks postpartum ($p=0.001$) and remained low at 6 months postpartum. Intake of milk and milk products increased significantly between baseline and 2 weeks post-intervention ($p=0.010$) and then decreased back to baseline values at 6 weeks ($p<0.001$) and decreased further at 6 month postpartum ($p=0.001$). A trend was seen in the intake of the others food group, where there was a significant increase (using paired t-tests) between 2 weeks post-intervention and 6 weeks postpartum ($p=0.002$), however, the mean intake did not remain significantly high at 6 months postpartum. No significant differences were observed in the mean intakes of grain products, meat and alternatives, and (HEI) scores.

Table 10
Meal Frequency, Intake of the Four Food Groups, and Healthy Eating Index (HEI) scores.

Variable	Baseline data Prior to Intervention (n=19)	2-3 weeks After Intervention (n=19)	6 wks Postpartum (n=19)	6 months Postpartum (n=11)	P value
Meal Frequency (# meals/day)	4.1[a]	5.5[b]	4.3[a]	3.9[a]	<0.001[1]
Grain Products	6.0[2]	7.1	6.7	7.2	0.423
Vegetable and Fruit Group	5.3[a]	5.8[a]	4.2[b]	4.9[b]	0.010
Milk and Milk Products	2.5[a]	3.5[b]	2.1[a]	1.4[c]	<0.001
Meat and Alternates	2.0	2.4	2.1	2.3	0.427
The Others Food Group	13.8[a]	8.5[a]	15.7[b]	17.7[a]	0.056
HEI	69.6[3]	74.4	65.0	66.9	0.275

[a,b,c] Indicate statistical significance of change between assessment points, using paired T-tests ($p<0.01$) to determine where these significant changes occurred between assessment points.
[1] $p<0.05$ indicates change at any time point using General Linear Repeated Measures Test
[2]Results presented as mean intake
[3] Maximum score of 100 as discussed in Chapter Three (p.43)

Table 11 represents servings of food in each food group compared to the Canada's Food Guide. Means intakes of Grain Products and Meats and Alternatives met the recommended guidelines at all four assessment points. Mean intakes of the Vegetable and Fruit Group met the recommended range at baseline and at 2 weeks post-intervention but not at 6 weeks and 6 months postpartum. Mean intakes of Milk Products met the recommended guidelines at all assessment points except at 6 months postpartum. The "Others Food Group" consists of foods high in oils, fats, and sugar using Canada's Food

Guide to Healthy Eating. The Others Food Group was quantified using the Food Processor Nutrient Analysis Software Version 7.50. There is no recommended range for this group but rather to use these foods in moderation according to Canada's Food Guide to Healthy Eating. Intakes had a tendency to decrease after intervention and then increase to above baseline values.

Table 11
Number of Servings of the Food Groups compared to recommended levels.

Variable	**Baseline Data** (n=19)	**2 weeks Post-Intervention** (n=19)	**6 wks Postpartum** (n=19)	**6 months Postpartum** (n=11)	**Recommended**
Grain[1] Products	6.0[2]	7.1	6.7	7.2	**5 to 12 servings**
Vegetable and Fruit Group	5.3	5.8	4.2	4.9	**5 to 10 servings**
Milk and Milk Products	2.5	3.5	2.1	1.4	**2 to 4 servings**
Meat and Alternates	2.0	2.4	2.1	2.3	**2 to 3 servings**
Others Food Group	13.8	8.5	15.7	17.7	**Use in moderation**

[1] Number Servings of all Four Food Groups as Recommended by the Canada's Food Guide to Healthy Eating, 1992 (Appendix A).
[2] Results presented as mean intake

Table 12 represents a summary ofthe previously mentioned key diabetes and pregnancy related dietary variables. The data is presented as shorterm (baseline and post-intervention) and longterm (6 weeks and 6 months postpartum) changes in relation to baseline values and whether the specific key variable increased or decreased beyond baseline values. In summary, significant increases (compared to baseline values) over the

shorterm were seen for the following variables: type (dietary fibre) and distribution (meal frequency) of carbohydrate, protein, and milk and milk products. Furthermore, significant decreases (compared to baseline values) over the longterm were seen for the following variables: calcium, vitamin D, vegetable and fruit group, and milk and milk products.

Table 12
Summary of Key Dietary Variables.

Shorterm	**2 weeks Post-Intervention**	**Some Improvement**
		CHO type- (g fibre)
		CHO distribution (#meals/day)
		Protein (g/day)
		Milk and Milk Products (svg/day)
Longterm	**6 weeks Postpartum**	**Return to Baseline**
		CHO type- (g fibre)
		CHO distribution (#meals/day)
		Protein (g/day)
		Milk and Milk Products (svg/day)
		Significant Decrease Beyond Baseline Values
		Vegetable and Fruit Group (svg/day)*
	6 months Postpartum	**Remained Low at 6 months postpartum**
		CHO type- (g fibre)
		CHO distribution (#meals/day)
		Protein (g/day)
		Milk and Milk Products (svg/day)
		Significant Decrease Compared to 6 weeks postpartum
		Calcium (mg/day)*
		Milk and Milk Products (svg/day)
		Significant Decrease Beyond Baseline Values
		Vitamin D (μg/day)*

* Represents those variables that did not show any improvement post-intervention but decreased throughout the postpartum period.

b. Postpartum Weight Maintenance and Body Composition

Table 13 depicts body weight for all four assessment points compared to prepregnancy weight. No significant differences were found among the measurements of mean body weight at any assessment point. Mean weight at 6 weeks and 6 months postpartum did not return to prepregnancy weight. Twelve out of 19 (63%) study participants did not return to prepregnancy body weight at the 6 weeks assessment. Seven out of eleven study participants (64%) did not return to prepregnancy body weight at both the 6 week and 6 month postpartum assessment points.

Table 13
Mean Weight Compared to Prepregnancy Weight.

Variable	**Normal** (Prepregnancy Weight) (n=19)	**Baseline Data** (n=19)	**2 weeks Post-Intervention** (n=19)	**6 wks Postpartum** (n=19)	**6 months Postpartum** (n=11)	**P value**
Weight (kg)	73.9[1] ± 21.5	82.6 ±23.5 (Pregnant)	82.8 ± 23.5 (Pregnant)	75.6 ±21.9	76.4 ± 24.1	0.163[2]

[1] Results presented as mean ± standard deviation
[2] Excludes baseline and 2 weeks post-intervention measurements.

Table 14 depicts values for BMI, waist circumference, and percent body fat at 6 weeks and 6 months postpartum assessment points, compared to normal ranges. Mean BMI did not meet normal BMI levels at either the 6 weeks or 6 month postpartum assessment points. Eleven out of the nineteen (56%) study participants at 6 weeks and six out of eleven study participants (55%) at 6 months did not achieve a BMI equal to or less than their prepregnancy BMI. Mean waist circumference at the 6 week and 6 month postpartum assessment points did not meet recommended waist circumference measurements. Nine out of nineteen study participants (47%) had a waist circumference ≥88 cm at 6 weeks postpartum. Six out of eleven study participants (55%) had a waist

circumference ≥88 cm at 6 months postpartum. Mean percent body fat at both 6 weeks and 6 months postpartum did not meet normal adult health standards. Sixteen out of nineteen study participants (84%) had a percent body fat >25% at 6 weeks postpartum. Nine out of eleven study participants (82%) had a percent body fat >25% at 6 months postpartum.

Table 14
Mean BMI, Waist Circumference, and Percent Body Fat Compared to Normal Values.

Variable	**6 weeks Postpartum** (n=19)	**6 months Postpartum** (n=11)	**Normal**
BMI (kg/m^2)	28.9[1] ± 7.3	29.1 ± 8.0	20.0 to 24.9 (Nonpregnant)
Waist Circumference(cm)	92.1 ± 16.8	92.2 ± 16.1	≤88 cm[2]
Body Fat (%)	35.3 ± 8.8	35.1 ± 10.9	25% >35% indicates Obesity

(Manual of Clinical Dietetics, 2000;Lohman et al, 1997)
[1] Results presented as mean ± standard deviation
[2] ≥88 cm in women may indicate increased risk for cardiovascular disease and Type 2 Diabetes.

c. Measurement to determine risk of diabetes

i. Plasma glucose (OGTT) and Serum insulin

Table 15 represents mean fasting and 2-hour serum glucose at both the 6 weeks and 6 month postpartum assessment points. Table 16 represents the number of study participants who met the criteria for Impaired Fasting Glucose (IFG), Impaired Glucose Tolerance (IGT), or Diabetes Mellitus (DM) at either the 6 week or the 6 month postpartum assessment points. Fourteen out of nineteen (74%) and five out of eleven (45%) study participants had normal blood glucose values at 6 weeks and 6 months

postpartum, respectively. Five out of nineteen study participants (26%) at 6 weeks postpartum, and five out of eleven study participants (45%) at 6 months postpartum, met the criteria for IGT. One out of eleven study participants met the criteria for the diagnosis of DM at 6 months postpartum.

Table 15
Mean Fasting and 2-hour Serum Glucose

Variable	**6 weeks postpartum** (n=19)	**6 months Postpartum** (n=11)
Fasting Plasma Glucose (mmol/L)	5.26[1] ± 0.75	5.48 ± 0.80
2-hour Plasma Glucose (mmol/L)	6.55 ± 1.68	7.59 ± 2.38

[1] Results presented as mean ± standard deviation

Table 16
Number of Study Participants Who Had Normal Blood Glucose Values and Those Who Meet the Criteria For IFG, IGT, and DM.

Variable	**Normal**	**Diagnosis for IFG[1]**	**Diagnosis for IGT[2]**	**Diagnosis for Diabetes Mellitus[3]**
6 weeks Postpartum (n=19)	14	0	5	0
6 months Postpartum (n=11)	5	0	5	1

(Canadian Diabetes Association, 1998)
[1] Impaired Fasting Glucose (IFG) diagnosed with a fasting glucose of 6.1 to 6.9mmol/L.
[2] Impaired Glucose Tolerance diagnosed with a 2-hour 75 g glucose load of 7.8 to 11.0 mmol/L.
[3] Diabetes Mellitus diagnosed with fasting glucose ≥7.0 mmol/L OR a 2-hour sample of the OGTT ≥11.0.

Table 17 represents mean fasting and 2-hour serum insulin levels at both the 6 week and 6 month postpartum assessment points. Mean fasting serum insulin fell within normal values at both 6 weeks and 6 months postpartum. However, mean 2-hour serum

insulin exceeded the normal value at both 6 weeks and 6 months postpartum. Ten out of nineteen (53%) study participants at 6 weeks postpartum ($x \pm SD = 52.1 \pm 25.7$) and eight out of eleven (73%) study participants at 6 months postpartum ($x \pm SD = 72.0 \pm 52.0$) had serum insulin concentrations above the normal adult ranges.

Table 17
Mean Fasting and 2-hour Serum Insulin .

Variable	6 weeks Postpartum (n=19)	6 months Postpartum (n=11)	Normal
Fasting Serum Insulin (mU/L)	8.37[1] ± 5.98	10.14 ± 7.39	5 to 20 mU/L
2-hour Serum Insulin (mU/L)	38.84 ± 26.89	66.93 ± 51.68	32 ± 17 mU/L

(University of Alberta Hospitals, 1994; Unpublished Data)
[1] Results presented as mean ± standard deviation.

ii. Lipid profile

Table 18 represents mean fasting serum total cholesterol (TC), high density lipoproteins cholesterol (HDL-C), low density lipoproteins-cholesterol (LDL-C), and triglycerides (TG) levels at both the 6 week and 6 month postpartum assessment points compared to desirable levels. Data for total cholesterol and LDL-C is presented in two different age categories according to standardized laboratory values (University of Alberta Hospitals, 1994). Mean total cholesterol levels at 6 weeks postpartum for both age categories were borderline high. Mean total cholesterol levels at 6 months postpartum was also borderline high for the 30-49 age group. Mean HDL-C levels at both 6 weeks and 6 months postpartum fell within desirable levels. Mean LDL-C cholesterol levels at 6 weeks postpartum was above desirable levels for the19-29 age group while mean LDL-C

cholesterol levels at both 6 weeks and 6 months postpartum were above desirable levels for the 30-49 age group. Mean TG levels at both 6 weeks and 6 months postpartum fell within desirable levels. Table 19 represents the number of study participants who did not meet desirable levels of Total Cholesterol, HDL-C, LDL-C, and TG.

Table 18
Mean Fasting Serum Total Cholesterol, HDL, LDL, and TG.

Variable	**6 wks Postpartum** (n=19)	**6 months Postpartum** (n=11)	**Normal**	
Total Cholesterol (mmol/L) 18-29 yrs	5.34[1] ±0.81	4.57 ±0.77	Desirable Borderline High High	<4.60 mmol/L 4.60 - 5.70 mmol/L >5.70 mmol/L
Total Cholesterol (mmol/L) 30-49 yrs	5.71 ± 1.07	5.92 ± 1.44	Desirable Borderline High High	<5.20 mmol/L 5.20 - 6.20 mmol/L >6.20 mmol/L
HDL-C (mmol/L)	1.36 ± .29	1.34 ±.37	Desirable	>0.90 mmol/L
LDL-C (mmol/L) 18-29 yrs	3.20 ± .58	2.55 ±0.38	Desirable	< 3.00 mmol/L
LDL-C (mmol/L) 30-49 yrs	3.63 ±1.03	3.74 ±1.40	Desirable	<3.40 mmol/L
TG (mmol/L)	1.84 ±1.29	1.69 ± 0.98	Desirable	<2.30 mmol/L

(University of Alberta Hospitals, 1994)
[1] Results presented as mean ± standard deviation

Table 19
Number of Study Participants Who Did Not Meet Desirable Levels of Serum Lipids.

Variable	6 wks Postpartum (n=19)	6 months Postpartum (n=11)
Total Cholesterol (mmol/L) 18-29 yrs	7	2
Total Cholesterol (mmol/L) 30-49 yrs	6	4
HDL-C (mmol/L)	0	1
LDL-C (mmol/L) 18-29 yrs	5	1
LDL-C (mmol/L) 30-49 yrs	4	3
TG (mmol/L)	4	3

d. Physical Activity

The types of activities study participants scheduled into their weekly routines are as follows in order of preference; walking, aerobics, yoga, and circuit training. At the baseline assessment point, the seventeen study participants who exercised regularly reported walking. At 6 weeks postpartum, of the thirteen study participants who exercised regularly, twelve study participants reported walking, and one reported yoga sessions. At 6 months postpartum, of the nine study participants who exercised regularly, seven reported walking, one reported yoga sessions, and one reported circuit training.

Table 20 represents mean expenditure of calories / week achieved during scheduled daily activity at three assessment points, baseline prior to the post-intervention, 6 weeks and 6 months postpartum. No significant differences in mean expenditure of calories / week were found between any of the assessment points.

Table 20
Mean Scheduled Exercise Energy Expenditure.

Variable	Baseline data Prior to Intervention (n=19)[1]	6 wks Postpartum (n=19)[2]	6 months Postpartum (n=11)[3]	P value
Calories (Kcal/week)	452[4] ±401	514 ± 888	461 ± 398	0.902[5]

[1] Two Study Participants did not participate in any form of Scheduled Daily Activity at Baseline.
[2] Six Study Participants did not participate in any form of Scheduled Daily Activity at 6 weeks postpartum.
[3] Two out of eleven Study Participants did not participate in any form of Scheduled Daily Activity.
[4] Results presented as mean ± standard deviation
[5] $p<0.05$ indicates change at any time point using General Linear Repeated Measures Test

Table 21 and 22 represent the frequency and duration of scheduled daily activity by the study participants at three assessment points, baseline prior to intervention, 6 weeks and 6 months postpartum. At the baseline assessment point, the majority of study participants' (36.8%) frequency of exercise fell into the sometimes once per week category and 31.6% exercised three or more times per week. At 6 weeks postpartum, 52.6% of the study participants reported exercising one to two times per week and at 6 months postpartum, 26.3% reported exercising one to two times per week. As indicated in Table 22, the majority of study participants exercised either ≤ 30 minutes or ≤ 1 hour each time, and for most it was <30 minutes per session.

Table 21
Frequency of Scheduled Daily Activity.

Frequency	**Baseline data Prior to Intervention** (n=19)	**6 wks Postpartum** (n=19)	**6 months Postpartum** (n=11)
≥ 3 times per week (%)	31.6[1]	5.3	10.5
1 to 2 times per week (%)	21.1	52.6	26.3
Sometimes once per week (%)	36.8	10.5	10.5
Never (%)	10.5	31.6	10.5

[1] Results presented as percentage of study participants

Table 22
Duration of Scheduled Daily Activity.

Duration	**Baseline data Prior to Intervention** (n=19)[1]	**6 wks Postpartum** (n=19)[2]	**6 months Postpartum** (n=11)[3]
≤ 30 minutes (# of participants)	12[4]	6	2
>30 minutes to ≤ 1 hour (# of participants)	4	6	6
> 1 hour to ≤ 1.5 hours (# of participants)	1	0	0
> 2 hours (# of participants)	0	1	1

[1] Two Study Participants did not participate in any form of Scheduled Daily Activity at Baseline.
[2] Six Study Participants did not participate in any form of Scheduled Daily Activity at 6 weeks postpartum.
[3] Two out of eleven Study Participants did not participate in any form of Scheduled Daily Activity.
[4] Results presented as number of study participants

C. Summary of Results - Hypotheses and Research Question

Hypothesis:

1. Women with GDM or IGT during pregnancy who receive nutrition education at diagnosis will make short-term* changes that will improve dietary intake and be sustained over the longterm* in;
   a) key diabetes related variables such as: amount, type, distribution and proportion of carbohydrates.
   b) key pregnancy and postpartum related variables: protein, calcium, folate, iron and Vitamin D, and the four food groups from Canada Food Guide.

   (*Short-term=post-intervention; Long-term=postpartum)

Hypothesis 1a was rejected, as it was found that there were significant findings to determine that women with GDM or IGT during pregnancy who received nutrition education at diagnosis did make short-term changes, which improved dietary intake, but these changes were not sustained over the longterm for key diabetes variables such as the type and distribution of carbohydrates. Total fibre and meal frequency all decreased post-intervention. Hypothesis 1b was rejected as there were significant findings to determine that women with GDM or IGT during pregnancy who received nutrition education at diagnosis did make short-term changes, which improved dietary intake, but these changes were not sustained over the longterm related to key pregnancy and postpartum variables such as: total protein, milk and milk product consumption. In addition, no significant increases were seen post-intervention with vitamin D, calcium and vegetable and fruit intake, however, all declined significantly in intake during the postpartum period.

Research Question

> Will women with GDM or IGT during pregnancy who receive nutrition education at diagnosis achieve normal values within the first 6 months postpartum for several of the risk factors for developing diabetes: weight management, fasting serum glucose, serum insulin, and serum lipids during the postpartum period?

Women with GDM or IGT during pregnancy who received nutrition education at diagnosis did not achieve normal values for several of the risk factors for diabetes, however, they did achieve postpartum weight management. No significant differences were found among mean body weight at any of the assessment points. Ten participants met the criteria for IGT at either the 6 weeks or 6 month postpartum assessment point; one participant met the criteria for the diagnosis of Type 2 Diabetes at 6 months postpartum. All but seven participants showed above normal values in 2-hour serum insulin levels at either the 6 week or 6 month postpartum assessment points. All but two participants demonstrated increased levels in at least one of the following variables: total cholesterol, LDL-C, and TG.

Chapter Five:
Discussion

A. Major Findings

The major finding of this research study was that there were shorterm improvements made in the dietary intakes of women with both GDM or IGT during pregnancy, however, these dietary modifications were not sustained during the postpartum period despite nutrition education upon diagnosis in the following variables: total fibre, meal frequency, total protein, and milk and milk product consumption. In addition, no shorterm changes were seen post-intervention in the dietary intakes of vitamin D, calcium and vegetable and fruit intake, where they all subsequently declined in intake during the postpartum period. This suggests that women with GDM or IGT during pregnancy may benefit greatly from the continued nutrition education received in clinic during pregnancy for a period of up to 6 months postpartum. The second major finding was that several women with GDM or IGT demonstrated abnormal postpartum values in blood glucose, serum insulin, and serum lipid levels placing them at a greater risk of developing Type 2 diabetes mellitus. These results further suggest that this group of women may benefit from continued postpartum follow up.

B. Participant Recruitment

Approximately 106 women with gestational diabetes mellitus (GDM) or impaired glucose tolerance (IGT) during pregnancy between the ages of 23 and 41 years were screened based on the study criteria. 49% of the women with GDM or IGT were

contacted by phone that resulted in a 16% response rate. This response rate is comparable to other studies that use similar recruitment strategies to those used in the present study. Neilsen and Tapsell (1994) had a 35% response rate when women with GDM were contacted by phone to participate in their study. Out of 62 women diagnosed with GDM over a three and a half year period, 25 could not be contacted, ten declined, two were pregnant, and one had developed Type 2 Diabetes. As a result, researchers from this study opted to focus on individual clinical results rather than group results. In another study Beischer, Wein, and Sheedy (1997) concluded that there were major difficulties with both recruiting women with GDM into a follow up program and ensuring continued attendance for detection of impaired glucose tolerance and diabetes mellitus. Their enrolment rate was as high as 58% most likely due to the postnatal OGTT acting as a strong initial motivater; however, the percentage of women remaining in the follow up program was only 21%. This group of investigators suggest the following to improve recruitment and follow-up in women with GDM: improved antenatal education about the importance of long-term follow up, a dedicated staff member to monitor delivery dates in order to visit them before discharge to arrange a follow-up visit, a computerized database to enable automatic recall, and meticulous attention to administrative detail.

The number of participants enrolled in the present study (n=29) was smaller than what was originally anticipated, and as a result, the study design was altered to reflect a case study series. To improve enrolment, alterations were made to the study design such as including women with IGT during pregnancy, increasing the age of participants screened, and individual considerations in the age of gestation. Total

recruitment may have been more successful had potential participants been contacted in-person during clinic visits as thirty participants were unavailable for telephone contact, but this was not feasible within the design of the study. In addition, some potential participants were not screened as a concurrent study was being conducted at the same area hospital sites. Throughout the course of the study, ten participants were lost to missed appointments at crucial assessment points, despite being contacted regularly. Up to twenty-nine women declined participation due to either time constraints, travel to and from additional postpartum appointments, childcare issues, or some were overwhelmed with their diagnosis of GDM/ IGT during pregnancy.

C. Dependent Measures

To evaluate dietary variables it was necessary to separate dietary variables important to diabetes from those dietary variables important to pregnancy, as both display different metabolic functions.

Key dietary variables related to diabetes were chosen based on their effects on blood glucose levels: type (dietary fibre), amount, distribution (meal frequency) and proportion (% of energy) of carbohydrates in the diet. This group of women with GDM or IGT during pregnancy made significant positive changes in the type and distribution of carbohydrates post-intervention. Results showed that mean intakes of dietary fibre and mean number of meals increased after nutrition education, however this was not sustained throughout the postpartum period. Additionally, total dietary fibre intake did not meet Dietary Reference Intakes (DRI) at any time point during this study except at post-intervention.

To date, it is not known whether dietary fibre improves glycemic control or pregnancy outcomes in women with GDM. However, longterm benefits of dietary fibre such as weight control, prevention of type 2 diabetes and cardiovascular disease, have been extensively investigated in populations both at risk of developing diabetes and those who are living with diabetes (Hu et al, 2001; Tuomilehto et al, 2001; Frost, Wilding, and Beecham, 1994). Studies have also shown that it is possible to reduce the risk of Type 2 diabetes where the diet consists of increased dietary fibre and low fat. Results in this study suggest that this group of women with GDM or IGT during pregnancy may benefit from further nutrition education during the postpartum period to help prevent Type 2 Diabetes by increasing total dietary fibre and perhaps increased meal frequency without increasing caloric intake.

Even though there is limited research to suggest any conclusive longterm benefits of increased meal frequency and the risk of developing diabetes in this population, it is important to note that this change was made after receiving nutrition education. Furthermore, increased meal frequency has been shown to influence insulin secretion and glucose tolerance by decreasing the need for insulin in non-pregnant individuals with diabetes. Therefore, increased meal frequency may be warranted as many women with GDM go on to exhibit abnormal insulin secretion and action (Ryan et al, 1995).

Key dietary variables important to pregnancy were chosen based on their increased requirements during pregnancy: protein, calcium, folate, iron and vitamin D, and the four food groups from the Canada Food Guide. Of those dietary variables specific to pregnancy, significant changes in calcium, vitamin D, and milk and milk products

were found. Both calcium and vitamin D being key nutrients in milk and milk products it was no surprise to find significant changes in this particular food group. Mean intake of both dietary calcium and milk and milk products, increased post-intervention but were not sustained during the postpartum period. In contrast, significant changes in dietary vitamin D were not seen in this group until late into postpartum where dietary vitamin D intake decreased at 6 months, and mean intake of dietary vitamin D met the DRI at the post-intervention visit only. Both calcium and vitamin D help to support bone integrity, skeletal development of the fetus, and the production of breastmilk (National Institute of Health, 1994). Results suggest that this group of women with GDM or IGT during pregnancy may have benefited from postpartum nutrition education to support adequate intake of calcium and vitamin D for breastfeeding and general health.

Although no significant changes were found for the dietary intakes of iron and folate, most women with GDM or IGT during pregnancy exhibited below RDA for all four micronutrients (calcium, folate, iron and vitamin D) assessed during and after their pregnancies. Other studies have demonstrated mean intakes of energy, calcium, magnesium, zinc, iron, folate, vitamin D, and vitamin E to be less than the estimated average requirements (EAR) in low-income, high-risk pregnant populations (Giddens J, Krug S, Tsang R, Guo S, Miodovnik M, & Prada J, 2000; Swensen A, Harnack L & Ross J, 2001). More recently, a study done by Turner R, LangKamp-Henken B, Littell R, Lukowski M and Suarex M (2003), demonstrated that in a population of middle- to upper-income low risk pregnant women, the mean dietary intakes of iron, magnesium, zinc, vitamin B6, selenium, and vitamin C were found to be less than the EAR.

There were no significant findings to indicate any change in macronutrient intake, except in the case of protein where mean intake increased post-intervention. This group of women with GDM or IGT during pregnancy met the DRI for all macronutrients. This finding differs from a similar study done by Neilson & Tapsell (1994). Neilson and Tapsell investigated dietary intake in GDM patients two to five and a half years following pregnancy and found that only one participant out of twenty-two continued to adhere to healthy eating guidelines (protein 12-20% of energy, fat <35% of energy, and carbohydrate >50% of energy). Although there were no significant changes in macronutrients, mean intake of vegetables and fruits increased significantly post-intervention but this change was not sustained throughout the postpartum period. In addition, the use of the Food Processor Nutrient Analysis 7.5 Software Program allowed us to track an additional 'Others' food group, which indicated a trend towards increased intakes of foods in this group that are higher in fats, oils, and sugars during the postpartum period. This finding paralleled with decreased vegetable and fruit intake during the postpartum period suggests a shift in overall intake of the four food groups.

Although the HEI scores did not exhibit any significant changes in overall diet quality, the total scores throughout the entire course of the study indicated that the diets of these women needed improvement. Therefore, based on individual dietary variables such as dietary fibre, calcium, vitamin D, milk and milk products, vegetables and fruit intakes, it would appear that the diets of women with GDM or IGT during pregnancy in this study declined during the postpartum period.

A recent study surveying the food habits of Canadians across four provinces found that women between the ages of twenty and thirty-nine years had low intakes of calcium, iron, folate, vegetables and fruit, and milk and milk products (Gray-Donald K, Jacobs-Starkey L, and Johnson-Down L, 2000). The results from the present study as mentioned above do indicate a similar trend of postpartum dietary intakes. However, most participants were taking prenatal supplements during pregnancy, which included vitamin D, calcium, folate and iron, although many participants did not continue to take this supplement during the postpartum period. Another finding of this Canadian survey was that the energy consumed by adult females from the 'others' food group was found to be as high as 27% (Pasut, L, 2001). A similar trend was seen in the present study where foods from the 'others' food group was found to be high in the diets of women with GDM or IGT during pregnancy during the postpartum period. The increase in the 'others' food group in theory ultimately leads to a shift in less nutrient dense foods and may explain why the RDA levels for micronutrients (dietary sources only) and dietary fibre were not met in this group of women with previous GDM or IGT during pregnancy. Therefore this group of women may have further benefited from follow up nutrition and lifestyle education to maintain general healthy eating guidelines. Such changes in diet intake are associated with the decreased risk of developing Type 2 Diabetes. Emphasis should be placed on healthy lifestyle behaviours, such as diet and exercise modifications, during the postpartum period. Long-term goals should include a diet rich in variety and dietary fibre and low in fat coupled with regular physical activity to help maintain a healthy weight. Both lifestyle factors, diet and physical activity,

can be modified to prevent weight gain during the postpartum period, which is a major risk factor in developing Type 2 Diabetes.

Factors influencing eating patterns such as the increased stress of having a new baby at home, perhaps limiting the time available to prepare healthy meals or achieve regular physical activity during the postpartum period were not investigated in this study. These factors perhaps, play an important role during this time period and should be considered when planning postpartum nutrition education programs for women with GDM or IGT during pregnancy.

To date there is limited research specific to the dietary intake of women with previous GDM and their longterm risk of Type 2 Diabetes. Most research in this area focuses on glycemic control during pregnancy of the women with GDM and fetal growth (Dornhorst and Frost, 2002). Research has shown that weight loss achieved by consuming low fat and high carbohydrate, high fibre diets, and increased physical activity, improves insulin sensitivity and decreases the risk of diabetes (Dornhorst & Frost, 1997; Hu et al, 2001). Recently, a study completed by the Diabetes Prevention Program Research Group (2002) demonstrated that intensive lifestyle intervention (one to one counselling on healthy low calorie diets low in fat) targeted at high risk groups including those with previous GDM, reduced the incidence of diabetes by 58% compared to the placebo group.

Results of the present study showed that women with GDM or IGT during pregnancy who received nutrition education upon diagnosis returned to self reported prepregnancy weight during the postpartum period, as there were no significant differences found between postpartum weight and prepregnancy weight. Women with

higher prepregnancy BMIs (BMI >27) are at risk of higher weight retention at one year postpartum (Keppel K & Taffel S, 1990; Ohlin A & Rossner S, 1990;Greene G, Smicklas-Wright H, Scholl T, & Karp R, 1988). Postpartum weight gain can put women at an increased risk of developing Type 2 Diabetes and GDM in subsequent pregnancies (O'Sullivan, 1982; Moses, 1996). It has been found that a weight gain of up to 10 to 20 kg over a four year period can double the risk of developing diabetes; and that women weighing more than 70 kg can experience a much greater risk of developing diabetes compared to those weighing 55 kg (Colditz G, Willett W, Stampfer M et al, 1990). This group of women had a mean prepregnancy weight of 73.9 kg (BMI 28.9) and a mean postpartum weight at 6 months of 76.4 kg (BMI 29.1) suggesting that this group of women with GDM or IGT during pregnancy could be at a greater risk of developing later onset of diabetes and may benefit from postpartum follow up related to weight management.

In addition, increased waist circumference and waist to hip ratios have been reported to be associated with glucose intolerance during pregnancy. (Branchtein L, Schmidt M, Mengue S et al, 1997) Mean postpartum waist circumference of women with GDM or IGT during pregnancy from this study was 92.1 cm and 92.2 cm at 6 weeks and 6 months postpartum, respectively. Waist circumference helps to identify those at increased health risk within normal weight, overweight, and obese BMI categories (Janssen I, Katzmarzyk P, & Ross R, 2002). It has been reported that those subjects with high waist circumference values (>88cm for women) were more likely to have hypertension, diabetes, dyslipidemia, and the metabolic syndrome also known

as insulin resistance syndrome compared to those individuals with normal waist circumference values (Janssen I, Katzmarzyk P, & Ross R, 2002).

Many of the women with GDM or IGT during pregnancy in this study were found to have abnormal values for serum glucose, serum insulin, total cholesterol, LDL-C, and TG. Ten participants met the criteria for IGT at either the 6 weeks or 6 month postpartum assessment point; one participant met the criteria for the diagnosis of Type 2 Diabetes at 6 months postpartum. All but seven participants showed increased values in the 2-hour serum insulin levels. All but two participants demonstrated increased levels in at least one of the following variables: total cholesterol, LDL-C, and TG.

Even though it was not our intention to investigate insulin resistance, it has been suggested by others that GDM is one phase of the insulin resistance syndrome (IRS) as many of the metabolic components of IRS are predictive of GDM (Clark C, Chunfu Q, Amerman B, Porter B, Fineberg N, Aldassouqi S et al, 1997; Verma A, Boney C, Tucker R & Vohr B, 2002). Insulin resistance is defined as the "inability of a known quantity of exogenous or endogenous insulin to increase glucose uptake and utilization in an individual as much as it does in a normal population" (Lebovitz, 2001). IRS is characterized by glucose intolerance, hyperinsulinemia, dyslipidemia, obesity, and hypertension. In 1996, Meyers-Seifer and Vohr investigated lipid levels in women with previous GDM at 5 to 6 years postpartum. Their study demonstrated that mean total cholesterol, LDL-C, TG, glucose, and systolic blood pressure were significantly higher in women with previous GDM compared to normoglycemic controls. Verma et al (2002) investigated IRS in women with previous GDM using the IRS diagnosis

criteria recommended by the Expert Panel on Detection, Evaluation and Treatment of High Blood Cholesterol in Adults. Criteria for the diagnosis of IRS is meeting a minimum of two of the following criteria; waist/hip ratio ≥0.85 or waist circumference ≥88 cm, systolic BP ≥130 mmHg or diastolic BP ≥85 mmHg, fasting blood glucose ≥6.1 mmol/L or postprandial blood glucose ≥7.8 mmol/L, HDL <1.3 mmol/L or fasting TG ≥1.7 mmol/L. They found that 27% of the women with previous GDM compared to 8% of controls developed IRS eleven years postpartum.

Nonetheless, it is well established by researchers that increased prepregnancy body mass index (BMI), increased glucose intolerance during pregnancy, and the presence of increased glucose values on the postpartum oral glucose tolerance tests (OGTT) all predict future onset of diabetes in women with GDM. The risk of developing diabetes postpartum is approximately 50% and the risk of developing impaired glucose tolerance can be as high as 75% (Ryan, 2001; Kjos et al, 1995; Pallardo et al, 1999; Ali & Alexis, 1990). There are striking similarities between GDM and IRS; both contributing risk factors to developing Type 2 diabetes.

Hormonal status has been associated with plasma lipid variation in women (Brizzi P, Tonolo G, Esposito F, Puddu L, Dessole S, Maioli M, & Milia S, 1999). HDL cholesterol levels have been shown to both decrease and increase, whereas total cholesterol, LDL, and TG levels have all been shown to progressively increase throughout normal pregnancy, mainly due to the increase in estrogen and progesterone levels, and return to normal by 6 weeks postpartum. Increased lipid levels during pregnancy are necessary to fulfill energy stores of maternal and fetal metabolic needs (Loke D, Viegas O, Kek L, Rauff M, Thai A, & Ratnam S, 1991). Although

controversial, GDM has been shown to alter lipid metabolism resulting in elevated levels of TG and lower concentrations of HDL (Knopp R, Chapman M, Bergelin R, Wahl P, Warth M & Irvine S, 1980; Hollinworth D & Grundy S, 1982; Metzger B, Phelps R, Freinkel N & Navickas I, 1980). This inverse relationship is consistent with characteristics of those patients diagnosed with diabetes (National Cholesterol Education Program, 2001). Conversely, Kjos S, Buchanan T, Montoro M, Coulson A, and Mestman J (1991) reported mildly elevated TG and decreased HDL only in women with previous GDM during a 36 month postpartum follow up period.

To date, there are still very few studies and relatively little is known about the changes in lipid metabolism during pregnancies complicated by GDM (Koukkou E, Watts & Lowy C, 1996) It has been suggested that as pregnancy evokes insulin resistance and metabolic adaptations causing major shifts in all metabolic fuels, that perhaps in women with GDM, greater glucose intolerance creates greater metabolic shifts (Chiang A, Yang M, Hung J, Chou P, Shyn S & Ng H, 1995; Koukkou al, 1996). It has also been shown that hyperlipidemia during pregnancy is sensitive to dietary manipulation and responds quickly to changes in cholesterol and fatty acid composition of foods (Potter J & Nestel P, 1976). Therefore, it could be hypothesized that a decline in diet during the postpartum period could indeed alter lipid levels. Even though results from this study indicate a general decline in the postpartum diets of women with either GDM or IGT during pregnancy, small sample size and lack of baseline values for serum lipids, limit our ability to speculate on the influence of diet during the postpartum period on their serum lipid levels.

D. Summary

Although research has convincingly demonstrated that maintaining a healthy lifestyle, which includes a diet rich in variety and fibre and low in fat coupled with regular physical activity to help maintain a healthy weight, can prevent Type 2 Diabetes there is limited research in this area in women with previous GDM or IGT during pregnancy. This population represents great potential in the prevention of Type 2 diabetes. This study is one of the few to date to investigate whether education on key nutrition modifications obtained upon diagnosis are maintained into the postpartum period in women with gestational diabetes mellitus. It was found that women with GDM or IGT during pregnancy made dietary modifications after receiving nutrition education, however, these changes were not sustained over the postpartum period. In addition, many aspects of their postpartum diets did not meet general healthy eating guidelines set out for the Canadian population at large. Despite poor dietary intake during the postpartum period, this group of women with GDM or IGT during pregnancy did achieve self reported prepregnancy weight. Nonetheless, it is possible that this group of women may have benefited from postpartum nutrition education aimed at decreasing their risk of Type 2 diabetes over the longterm. A noteworthy observation was that many of the women with GDM or IGT during pregnancy in this study were found to have abnormal values for serum glucose, serum insulin, total cholesterol, LDL-C, and TG levels. Due to the small sample size used in this study, the results must be regarded as preliminary. Further research is required to determine definitively whether nutrition education provided upon diagnosis of GDM

or IGT during pregnancy is effective in sustaining dietary modification throughout the postpartum period.

E. Limitations of the Study

The main limitation of this study was the small sample size. Results from this study with a larger sample size, may have potentially enabled us to draw conclusions about the dietary intake of this population.

Perhaps prepregnancy weights could have been obtained through past medical records rather than relying on self reported prepregnancy weights from study participants. However, standardized prepregnancy weight measurements may not necessarily be reported in medical charts. Finally, a more comprehensive assessment of physical activity may have enhanced our understanding of lifestyle factors during the postpartum period. Study design limited the amount of time with study participants in the clinic and therefore questions regarding physical activity were limited to frequency, duration and intensity where only scheduled daily activity was reviewed and considered by the researcher.

F. Future Research

Most research in this area focuses on glycemic control during pregnancy of women with GDM and fetal outcomes. This is only the second study to date to investigate whether nutrition education provided at diagnosis resulted in improved dietary intake and was sustained into the postpartum period in women with GDM. More research is needed before definite conclusions can be made on this issue.

Currently there is a study underway called Hyperglycemic Adverse Pregnancy Outcome (HAPO) "[investigating] 25,000 pregnant women, many with lesser degrees of glucose intolerance who will have received no special medical or dietary input" where it is hoped it will help to establish at what degree of glucose intolerance dietary management should be offered (Dornhorst and Frost, 2002). Research is needed to investigate the longterm implications of postpartum nutrition education programs and its impact on the prevalence of Type 2 diabetes in this population. Such research should include longterm strategies to maintaining a healthy weight including a diet rich in variety and dietary fibre and low in fat coupled with regular physical activity.

Literature Cited

Ali Z and Alexis SD. Occurrence of diabetes mellitus after gestational diabetes mellitus in Trinidad. Diabetes Care 1990;13:527-29.

American Diabetes Association. Evidence-Based Nutrition Principles and Recommendations for the Treatment and Prevention of Diabetes and Related Complications Diabetes Care 2003;26:S51-S61.

American Diabetes Association. Gestational Diabetes Mellitus. Diabetes Care 1998;21(Suppl 1):S60-S61.

American Diabetes Association. Gestational Diabetes Mellitus. Diabetes Care 1999;22(Suppl 1):S74-76.

Ardern C, Katzmarzyk P, Janssen I, and Ross R. Discrimination of Health Risk by Combined Body Mass Index and Waist Circumference. Obesity Research 2003;11(1):135-42.

Bartha JL, Martinez-Del-Fresno P and Comino-Delgado R. Gestational Diabetes Mellitus Diagnosed During Early Pregnancy. American Journal of Obstetrics and Gynecology 2000;182(2):346-50.

Beischer N, Wein P, and Sheedy M. A Follow-Up Program for Women With Previous Gestational Diabetes Mellitus. Medical Journal of Australia 1997;166:353-7.

Block G. A review of validations of dietary assessment methods. American Journal of Epidemiology 1982 115:492-505.

Bowes SB, Hennessy TR, Umpleby AM, Benn JJ, Jackson NC, Boroujerdi MA, Sonksen PH, and Lowy C. Measurement of Glucose Metabolism and Insulin Secretion During normal Pregnancy and Pregnancy Complicated by Gestational Diabetes. Diabetologia 1996;39(8):976-83.

Bowman S, Lino M, Gerrior S, and Basiotis P. The Healthy Eating Index 1994-96. United States Department of Agriculture. Centre for Nutrition Policy and Promotion.

Branchtein L, Schmidt M, Mengue S et al. Waist circumference and Waist-to-Hip Ratio are Related to Gestational Glucose Tolerance. Diabetes Care 1997;20:509-511.

Breschi MC, Seghieri G, Bartolomei G, Gironi A, Baldi S, and Ferrannini E. Relation of birthweight to maternal plasma glucose and insulin concentrations during normal pregnancy. Diabetologia 1993;36(12):1351-21.

Brizzi P, Tonolo G, Esposito F, Puddu L, Dessole S, Maioli M, and Milia S. Lipoprotein Metabolism During Normal Pregnancy. Obstetrics and Gynecology 1999;181:430-4.

Bung P, Artal R, Khodiguian N, Kjos S. Exercise in Gestational Diabetes. An Optional Therapeutic Approach? Diabetes 1991;40(Suppl 2):182-185.

Canadian Diabetes Association. Guidelines for the Nutritional Management of Diabetes During Pregnancy. A Position Statement by the Canadian Diabetes Association. Beta Release 1991;15(3):75-82.

Canadian Diabetes Association. Guidelines for the Nutritional Management of Diabetes Mellitus in the New Millennium: A Position Statement by the Canadian Diabetes Association. Canadian Journal of Diabetes Care 23(3):56-69.

Canadian Diabetes Association, National Nutrition Committee. Guidelines for the Nutritional management of Diabetes in Pregnancy. Beta Release 1991;15(3):75-82.

Carbohydrates in Human Nutrition. Report of a joint FAO/WHO Expert Consultation, Rome, 14-18 April, 1997. FAO Food and Nutrition Paper 66. Rome, 1998.

Catalano P, Bernstein I, Wolfe R, Srikanta S, Tyzbir E, and Sims E. Subclinical Abnormalities of Glucose Metabolism in Subjects with Previous Gestational Diabetes. American Journal of Obstetrics and Gynecology 1986;155:1255-62.

Catalano PM. Effect of maternal metabolism on fetal growth and body composition. Diabetes car 1998;21(Suppl 2):B85-90.

Catalano PM, Vargo KM, Berstein IM and Amini SB. Incidence and Risk Factors Associated with Abnormal Postpartum Glucose Tolerance in Women with Gestational Diabetes. American Journal of Obstetrics and Gynecology 1991;165:914-19.

Cellier KM and Hankin ME. Studies of nutrition in pregnancy. I. Some considerations in collecting dietary information. American Journal of Clinical Nutrition 1963;13:55-62.

Chiang A, Yang M, Hung J, Chou P, Shyn S, and Ng H. Alterations of Serum Lipid Levels and Their Biological Relevance During and After Pregnancy. Life Sciences 1995;56(26):2367-75.

Clapp J. Effect of Dietary Carbohydrate on the Glucose and Insulin Response to Mixed Caloric Intake and Exercise in Non-Pregnant and Pregnant Women. Diabetes Care 1998 21(Suppl 2):B107-112.

Clark C, Chunfu Q, Amerman B, Porter B, Fineberg N, Aldassouqi S et al. Gestational Diabetes: Should It Be Added to the Syndrome of Insulin Resistance? Diabetes Care 1997;20(5):867-71.

Colditz G, Willett W, Stampfer M et al. Weight as a risk factor for clinical diabetes in women. American Journal of Epidemiology 1990;132:201-13.

Cornblath M and Schwartz R. Disorders of carbohydrate Metabolism in Infancy. Philadelphia:WB Saunders; 1976.

Coustan DR, Carpenter MW, O'Sullivan PS and Carr SR. Gestational Diabetes: Predictors of Subsequent Disordered Glucose Metabolism. American Journal of Obstetrics and Gynecology 1993;168:1139-45.

Damm P, Kuhl C, Bertelsen A and Molsted-Pedersen L. Predictive Factors for the Development of Diabetes in Women with Previous Gestational Diabetes Mellitus. American Journal of Obstetrics and Gynecology 1992;167:607-16.

DeFronzo R and Ferrannini E. Insulin Resistance: A Multifaceted Syndrome Responsible for NIDDM, Obesity, Hypertension, Dyslipidemia, and Atherosclerotic vascular Disease. Diabetes Care 1991;14:173-194.

De Veciana M, Major CA, Morgan MA, Asrat T, Toohey JS, Lien JM and Evens AT. Postprandial versus Preprandial Blood Glucose Monitoring in Women With Gestational Diabetes Mellitus Requiring Insulin Therapy. The New England Journal of Medicine 1995;333(19):1237-41.

Diabetes Prevention Program Research Group. Reduction in the Incidence of Type 2 Diabetes with Lifestyle Intervention or Metformin. The New England Journal of Medicine 2002 346(6):393-403.

Dornhorst A and Frost G. The Potential for Dietary Intervention Postpartum in Women with Gestational Diabetes. Diabetes Care 1997;20(11):1635-6.

Dornhorst A and Frost G. The Principles of Dietary Management of Gestational Diabetes: Reflection on Current Evidence. Journal of Human Nutrition and Dietetics 2002;15(2):145-6.

Dornhorst A and Rossi M. Risk and Prevention of Type Diabetes in Women With Gestational Diabetes. Diabetes Care 1998;21(Suppl 2):B43-9.

Engelgau MM, Herman WH, Smith PJ, German RR, and Aubert RE. The Epidemiology of diabetes and pregnancy in the US. Diabetes Care 1995;18:1029-33.

Eriksson K-F and Lingarde F. Prevention of Type 2 (Non-Insulin-Dependent) Diabetes Mellitus by Diet and Physical Exercise. Diabetologia 1991;34:891-8.

2001 Executive Summary of the Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). Journal of The American Medical Association 2001;285:2486-97.

Fagen C, King JD and Erick M. Nutrition Management in Women With Gestational Diabetes Mellitus: A Review by ADA's Diabetes Care and Education Dietetic Practice Group. Journal of the American Dietetics Association 1995;95:460-7.

Farrell T, Neale L, and Cundy T. Congenital Anomalies in the Offspring of Women with Type 1, Type 2 and Gestational Diabetes. Diabetes Medicine 2002;19(4):322-6.

Forsbach G, Conteras Soto JJ, Fong G, Flores G, and Moreno O. Prevalence of gestational diabetes and macrosomic newborns in Mexican populations. Diabetes Care 1988;11:235-38.

Foster-Powell K, Holt SHA, and Brand-Miller JC. International Table of Glycemic Index and Glycemic Load Values:2002. American Journal of Clinical Nutrition 2002;76:5-56.

Fraser RB and Bruce C. Amniotic Fluid Insulin Levels Identify the Fetus at Risk of Neonatal Hypoglycemia. Diabetic Medicine 1999;16:568-572.

Fraser R, Ford F, and Lawrence G. Insulin Sensitivity in Third Trimester Pregnancy. A Randomized Study of Dietary Effects. British Journal of Obstetrics and Gynecology 1988;95:223-9.

Freinkel N. Banting Lecture 1980:of Pregnancy and Progeny. Diabetes 1980;29:1023-35.
Gaudier FL, Hauth JC, Poist M, Corbett D, Cliver SP. Recurrence of Gestational Diabetes Mellitus. Obstetrics and Gynecology 1992;80:755-758.

Frost G, Wilding J and Beecham J. Dietary Advice Based on the Glycemic Index Improves Dietary Profile and Metabolic Control in Type 2 Diabetes Patients. Diabetes Medicine 1994;11:397-401.

Garcia-Patterson A, Martin E, Ubeda J, Maria MA, De Leiva A and Corcoy R. Evaluation of Light Exercise in the Treatment of Gestational Diabetes. Diabetes Care 2001;24(11):2006-7.

Giddens J, Krug S, Tsang R, Guo S, Miodvnik M and Prada J. Pregnant Adolescent and Adult Women Have Similar Low Intakes of Selected Nutrients. Journal of the American Dietetic Association 2000;100:1334-1340.

Gray-Donald K, Jacobs-Starkey L and Johnson-Down L. Food Habits of Canadians: Reduction in Fat Intake Over a Generation. Canadian Journal of Public Health 2000;91(5):381-385.

Greene G, Smicklas-Wright H, Scholl T, Karp R. Postpartum Weight Change: How Much of the Weight Gained in Pregnancy Will Be Lost After Delivery? Obstetrics and Gynecology 1998:71:701-7.

Gunderson EP. Intensive Nutrition Therapy for Gestational Diabetes. Rationale and Current Issues. Diabetes Care 1997;20(2):221-6.

Hann CS, Rock CL, King I and Drewnowski A. Validation of the Healthy Eating Index with Use of Plasma Biomarkers in a Clinical Sample of Women. American Journal of Clinical Nutrition 2001;74:479-86.

Harris SB, Caulifield LE, Sugamouri ME, Whalen EA, and Henning B. The Epidemiology of diabetes in pregnant native Canadians. Diabetes Care 1997;20:1422-25.

Health Canada. Nutrition for a Healthy Pregnancy: National Guidelines for the Childbearing Years. Ottawa: Minister of Public Works and Government Services Canada, 1999.

Health Canada. Nutrition Recommendations. The Report of the Scientific Review Committee. Minister of Supply Services Canada, 1990.

Health and Welfare Canada. Action Towards … Canada's Guidelines for Healthy Eating and Recommended Strategies for Implementation. The Report of the Communications/Implementation Committee. Ottawa: Minister of Supply and Services Canada;1990.

Hod M, Merlob P, Friedman S, Rusecki Y, Schoenfeld, and Ovadia J. Prevalence of congenital anomalies and neonatal complications in the offspring of diabetic mothers in Isreal. Isr J Med Sci 1991;27:498-502.

Hod M, Rabinerson D, Kaplan B, Peled Y, Bar J, Shindel B, Merlob P, Ovadia J, Neri A. Perinatal complications following gestational diabetes mellitus how 'sweet' is ill? Acta Obstet Gynecol Scand 1996;75(9):809-15.

Hollingsworth DR. Alterations of Maternal Metabolism in Normal and Diabetic Pregnancies: Differences in Insulin-Dependent, Non-Insulin-Dependent, and Gestational Diabetes. American Journal of Obstetrics and Gynecology 1983;146:417-29.

Hollinworth D and Grundy S. Pregnancy Associated Hypertriglyceridemia in Normal and Diabetic Women 1982;31:1092-7.

Homko CJ, Sivan E and Reece EA. Is Self-Monitoring of Blood Glucose Necessary in the Management of Gestational Diabetes Mellitus? Diabetes Care 1998;21(Suppl 2):B118-B122.

Horton ES. Exercise in the Treatment of NIDDM. Applications for GDM? Diabetes 1991;40(Suppl 2):175-8.

Hu FB, Manson JE, Stampfer MJ, Colditz G, Liu S, Solomon CG, Willet W. Diet, Lifestyle, and Risk of Type 2 Diabetes Mellitus in Women. New England Journal of Medicine 2001;345(11):790-7.

Janssen I, Heymsfield S, Allison D, Kotler D, and Ross R. Body Mass Index and Waist Circumference Independently Contribute to the Prediction of Non-abdominal, Abdominal subcutaneous, and Visceral Fat. American Journal of Clinical Nutrition 2002;75(4):683-8.

Janssen I, Katzmarzyk P, and Ross R. Body Mass Index, Waist Circumference, and Health Risk: Evidence in support of Current National Institutes of Health Guidelines. Archives of Internal Medicine 2002;162(18):2074-9.

Jenkins DJ. Carbohydrate Tolerance and Food Frequency. British Journal of Nutrition 1997;77(Suppl. 1):S71-81.

Jenkins DJ, Jenkins AL, Wolever TM, Collier GR, Rao AV and Thompson LU. Starchy Foods and Fibre: Reduced Rate of Digestion and Improved Carbohydrate Metabolism. Scand J of Gastroenterology 1987 ;129:132-41.

Jovanovic L. American Diabetes Association's Fourth International Workshop-Conference on Gestational Diabetes Mellitus: Summary and Discussion. Therapeutic Interventions. Diabetes Care 1998;21(Suppl 2):B131-B137.

Jovanovic-Perterson L and Peterson CM. Dietary manipulation as primary treatment strategy for pregnancies complicated by diabetes. Journal of the American College of Nutrition 1990;9:320-5.

Jovanovic-Peterson L and Peterson CM. Is Exercise Safe or Useful for Gestational Diabetic Women? Diabetes 1991;40(Suppl 2):179-181.

Kautzky-Willer A, Prager R, Waldhausl W, Pacini G, Thomaseth K, Wagner OF, Ulm M, Streli C, and Ludvik B. Pronounced Insulin Resistance and Inadequate Beta-Cell Secretion Characterize Lean Gestational Diabetes During and After Pregnancy. Diabetes Care 1997;20(11):1717-23.

Kennedy ET, Ohls J, Carlson S, Flemming K. The Healthy Eating Index: design and applications. Journal of the American Dietetic Association 1995;95:1103-8.

Keppel G and Zedeck S. Data Analysis for Research Designs: Analysis of Variance and Multiple Regression/Correlation Approaches. W.H. Freeman and Company, 1989. Chapters 1,12, and 22;pp.10-11, 170-1, 478-9.

Keppel K and Taffel S. Pregnancy-Related Weight Gain and Retention: Implications of the 1990 Institute of Medicine Guidelines. American Journal of Public Health 1993;83:1100-3.

Kitzmiller JL, Hoedt LA, Gunderson EP, Theiss TS, Ceresa CL, Kitzmiller AM. Macrosomia and birth trauma in infants of diet treated gestational diabetic women. In gestational diabetes. Weiss Pam, Coustan DR, Eds. New York, Springer-Verlag, 1988, p.1-16.

Kjos SL, Buchanon TA, Greenspoon JS, Montoro M, Berstein GS, and Mestman JH. Gestational diabetes mellitus: The prevalence of glucose intolerance and diabetes mellitus in the first two months post partum. American Journal of Obstetrics and Gynecology 1990;163:93-98.

Kjos SL, Peters RK, Xiang A, Henry OA, Montaro M, Buchanan TA. Predicting Future Diabetes in Latino Women with Gestational Diabetes. Utility of Early Postpartum Glucose Tolerance Testing. Diabetes 1995;44:586-91.

Knopp R, Chapman M, Bergelin R, Wahl P, Warth M and Irvine S. Relationships of Lipoprotein Lipids to Mild Fasting Hyperglycemia and Diabetes in Pregnancy. Diabetes Care 1980;3:416-20.

Koukkou E, Watts, and Lowy C. Serum Lipid, Lipoprotein and Apolipoprotein Changes in Gestational Diabetes Mellitus: A Cross-Sectional and Prospective Study. Journal of Clinical Pathology 1996;49:634-7.

Kuhl C. Etiology and Pathogenesis of Gestational Diabetes. Diabetes Care 1998;21(Suppl 2):B19-26.

Langer N and Langer O. Emotional Adjustment to Diagnosis and Intensified Treatment of Gestational Diabetes. Obstetrics and Gynecology 1994;84:329-334.

Langer O, Conway DL, Berkus MD, Xenakis EM, and Gonzales O. Comparison of Glyburide and Insulin in Women with Gestational Diabetes Mellitus. New England Journal of Medicine 2000;343:1134-38.

Langer O, Rodriguez DA, Xenaski EM, McFarland MB, Berkus MD, Arrendondo F. Intensified versus Conventional Management of Gestational Diabetes. American Journal of Obstetrics and Gynecology 1994;170(4):1036-46.

Larsson B, Svardsudd B, Welin L, Wilhelmsen L, Bjorntorp P, and Tibblin G. Abdominal adipose tissue distribution, obesity and risk of cardiovascular disease and death: 13 year follow-up of participants in the study of men born in 1913. British Medical Journal 1984;288:1401-1404.

Laverdiere J and Bell R. Selecting Carbohydrates for People With Diabetes. Part 1: Meeting Metabolic Goals. Clinical Nutrition Rounds April 2003;3(4).

Lobovitz H. Insulin Resistance: Definition and consequences. Experimental Clinical Endocrinology Diabetes 2001;109(Suppl 2):S135-48.

Lohman TG, Houtkooper L, Going SB. Body Fat Measurement goes high-tech: Not All Are Created Equal. ACMS's Health Fitness Journal 1997;7:30-5.

Loke D, Viegas O, Kek L, Rauff M, Thai A, and Ratnam S. Lipid Profiles During and After Normal Pregnancy. Gynecology and Obstetrical Investigation 1991;32:144-7.

Long SD, Swanson MS, O'Brien K, Pories WJ, MacDonald KG, Caro JF and Leggett-Frazier N. Weight Loss in Severely Obese Subjects Prevents the Progression of Impaired Glucose Tolerance to Type II Diabetes. Diabetes Care 1994;17(5):372-5.

Ludvik B, Nolan JJ, Baloga J, Sacks D, and Olefsky J. Effect of Obesity on Insulin Resistance in Normal Subjects and Patients with NIDDM. Diabetes 1995;44:1121-5.

Major CA, Henry J, De Viciana M and Morgan MA. The Effects of Carbohydrate Restriction in Patients With Diet-Controlled Gestational Diabetes. Obstetrics and Gynecology 1998:91:600-4.

Manual of Clinical Dietetics, 6th edition: American Dietetic Association and Dietitians of Canada. Chapter 20: Diabetes Mellitus - Nutrition Management. Library of Congress Cataloguing-in-Publication Datas, 2000, p.322-324.

McFarland M, Langer O, Conway D and Berkus M. Dietary Therapy for Gestational Diabetes: How Long Is Long Enough? Obstetrics and Gynecology 1999;93:978-82.

Metzger BE, Cho NH, Roston SM and Radvany R. Prepregnancy Weight and Antepartum Insulin Secretion Predict Glucose Tolerance Five Years After Gestational Diabetes Mellitus. Diabetes Care 1993;16(12):1598-1605.

Metzger BE & Coustan DR. Summary and Recommendations of the Fourth International Workshop-Conference on Gestational Diabetes Mellitus. Diabetes Care 1998;21(Suppl 2):B161-B167.

Metzger B, Phelps R, Freinkel N, and Navickas I. Effects of Gestational Diabetes on Diurnal Profiles of Plasma Glucose, Lipids and Individual Amino Acids. Diabetes Care 1980;3:402-9.

Meyers-Seifer C and Vohr B. Lipid Levels in Former Gestational Diabetic Mothers. Diabetes Care 1996;19(12):1351-6.

Mironiuk M, Kietlinska Z, Jerierska-Kasprzyk K, and Piekosz-Orzechowska B. A Class of Diabetes in Mother, Glycemic Control in Early Pregnancy and Occurrence of Congenital Malformations in Newborn Infants. Clinical Experiments in Obstetrics and Gynecology 1997;24(4):193-7.

Mooradian AD, Failla M, and Hoogwerf B, et al. Selected vitamins and minerals in diabetes. Diabetes Care 1994;17:464-79.

Moses RG. The Recurrence Rate of Gestational Diabetes in Subsequent Pregnancies. Diabetes Care 1996;19(12):1348-50.

Moses RG, Shand JL and Tapsell LC. The Recurrence of Gestational Diabetes: Could Dietary Differences in Fat Intake be an Explanation? Diabetes Care 1997;20:1647-50.

Nachum Z, Ben-Shlomo I, Weiner E, and Shalev E. Twice daily versus four times daily insulin dose regimens for diabetes in pregnancy: randomized controlled trial. British Medial Journal 1999;319:1223-27.

National Institute of Health. Optimal Calcium Intake. NIH Consensus Statement. 1994;Jun6-8(4):1-31.

Naylor CD, Sermer M, Chen E, and Sykora K. Caesarean delivery in relation to birth weight and gestational glucose tolerance: pathophysiology or practice style? Journal of the American Medical Association 1996;275:1165-70.

Neilson R and Tapsell L. Gestational Diabetes: Weight Control and Dietary Intake After Pregnancy. Australian Journal of Nutrition and Dietetics 1994;51:125-7.

Nunez C, Gallagher D, Visser M, Pi-Sunyer F, Wang Z, and Heymsfield S. Bioimpedance analysis: evaluation of leg-to-leg system based on pressure contact foot-pad electrodes. Medical Science of Sports Exercise 1997;29:524-31.

Nutrition and Your Health: Dietary Guidelines for Americans, 5th edition. Washington, D.C. : U.S. Department of Agriculture and Health and Human Services, 2000.

Ohlin A and Rossner S. Maternal Body Weight Development After Pregnancy. International Journal of Obesity 1990;14:159-70.

O'Sullivan JB. Body Weight and Subsequent Diabetes Mellitus. Journal of the American Medical Association 1982;248(8):949-52.

Pallardo F, Herranz L, Garcia-Ingelmo T, Grande C, Martin-Vaquero P, Janez M, Gonzalez A. Early postpartum metabolic assessment in women with prior gestational diabetes. Diabetes Care1999;22:1053-58.

Pan XR, Li GW, Hu YH, Wang JX, Yang WY, An ZX, Hu ZX, Lin J, Xiao JZ, Cao HB, Liu PA, Jiang XG, Jiang YY, Wang, Zheng H, Zhang H, Bennett PH, and Howard BV. Effects of diet and exercise in preventing NIDDM in people with impaired glucose tolerance. Diabetes Care 1997 20: 537-544.

Pasut L. Food Habits of Canadians: Changing Nutrition Issues. Beef Information Centre. 2001.

Pederson J. Weight and Length at Birth of Infants of Diabetic Mothers. Acta Endocrinology 1954;16:330-42.

Peterson CM and Jovanovic-Peterson L. Percentage of Carbohydrate and Glycemic Response to Breakfast, Lunch, and Dinner in Women with Gestational Diabetes. Diabetes 1991;40(Suppl. 2):172-74.

Pettit DJ, Bennett PH, Knowler WC, Baird R, and Aleck KA. Gestational Diabetes Mellitus and Impaired Glucose Tolerance During Pregnancy. Long-Term Effects on Obesity and Glucose Tolerance in the Offspring. Diabetes 1985;34(Suppl 2):119-22.

Philipson EH and Super DM. Gestational Diabetes Mellitus: Does it Recur in Subsequent Pregnancy? American Journal of Obstetrics and Gynecology 1989;16:1324-31.

Plagemann A, Harder T, Kohlhoff R, Rohde W, and Dorner G. Glucose Tolerance and Insulin Secretion in Children of Mothers with Pregestational IDDM or Gestational Diabetes. Diabetologia 1997;40:1094-1100.

Porter ML and Dennis BL. Hyperbilirubenemia in the Term Newborn. American Family Physicians 2002;64(4):599-606.

Potter J and Nestel P. The Effects of Dietary Fatty Acids and Cholesterol on the Milk Lipids of Lactating Women and the Plasma Cholesterol of Breast-fed Infants. American Journal of Clinical Nutrition 1976;29:54-60.

Reaven G. Role of Insulin Resistance in Human Disease. Diabetes 1988;37:1595-1607.

Remsberg KE, McKeown RE, McFarland KF, and Irwin LS. Diabetes in pregnancy and Caesarean delivery. Diabetes Care 1999;22:1567.

Romon M, Nuttens M, Vambergue A, Verier-Mine O, Biausque S, Lemaire C, Fontaine P, Salomez J, and Beuscart R. Higher Carbohydrate Intake is Associated With Decreased Incidence of Newborn Macrosomia in Women With Gestational Diabetes. Journal of the American Dietetic Association 2001;101:897-902.

Ryan EA and Enns L. Role of Gestational Hormones in the Induction of Insulin Resistance. Journal of Clinical Endocrinology Metabolism 1988;67(2):341-7.

Ryan EA. What is Gestational Diabetes? In: Gerstein Hc, Haynes RB, Eds. Hamilton: BC Decker Inc., 2001: 164-83.

Ryan EA, Imes S, Liu D, McManus R, Finegood DT, Polonsky KS, and Sturis J. Defects in Insulin Secretion and Action in Women with a History of Gestational Diabetes. Diabetes 1995;44:506-12.

Salmeron J, Ascherio A, Rimm E, Colditz G, Spiegelman D, Jenkins D, Stamper M, Wing A and Willett W. Dietary Fibre, Glycemic Load, and Risk of NIDDM in Men. Diabetes Care 1997;20(4):545-50.

Schafer U, Songster G, Xiang A, Berkowitz K, Buchanon TA, and Kjos SI. Congenital malformations in offspring of women with hyperglycaemia first detected in pregnancy. American Journal of Obstetrics and Gynecology 1997;177:1165-71.

Schwartz R. Neonatal Hypoglycemia: How Low is Too Low? The Journal of Pediatrics 1997;131(2):171-3.

Schwartz R and Teramo KA. What is the Significance of Macrosomia? Diabetes Care 1999;22:1201-05.

Senior B. Neonatal Hypoglycemia. The New England Journal of Medicine 1973;289(15):790-3.

Silverman BL, Metzger BE, Cho NH, and Loeb CA. Impaired Glucose Tolerance in Adolescent Offspring of Diabetic Mothers. Relationship to Fetal Hyperinsulinism. Diabetes Care 1995;18(5):611-17.

Solomon Cg, Willet WC, Carey VJ, Rich-Edwards J, Hunter DJ, Colditz GA, Stampfer MJ, Speizer FE, Spiegelman D, and Manson JE. A Prospective Study of Pregravid Determinants of Gestational Diabetes Mellitus. JAMA 1997;278:1078-83.

Steinhart JR, Sugarman JR, and Connell FA. Gestational Diabetes is a Herald of NIDDM in Navajo Women. High Rate of Abnormal Glucose Tolerance After GDM. Diabetes Care 1997;20(6):943-7.

Stenninger E, Scholin J, and Aman J. Neonatal Macrosomia and Hypoglycaemia in Children of Mothers with Insulin-Treated Gestational Diabetes Mellitus. Acta Paediatr Scand 1991;80(11):1014-8.

Swensen A, Harnack L and Ross J. Nutritional assessment of Pregnant Women Enrolled in the Special Supplemental Program for Women, Infants, and Children (WIC). Journal of the American Dietetic Association 2001;101:903-8.

Thompson DM, Dansereau J, Creed M, and Ridell L. Tight glucose control results in normal perinatal outcome in 150 patients with gestational diabetes. Obstet Gynecol 1994;83(3):362-66.

Tuomilehto J, Lindstrom MS, Eriksson JG, Valle TT, Hamalainen H, Ilanne-Prikka P, Keinanen-Kiukaanniemi S, Laakso M, Louheranta A, Rastas M, Salminen V, Aunola S, Cepasitis Z, Moltchanov V, Hakumaki M, Mannelin M, Martikkala V, Sundval J, Uusitupa M. Prevention of Type 2 Diabetes Mellitus by Changes in Lifestyle among

Subjects with Impaired Glucose Tolerance. New England Journal of Medicine 2001;344(18):1343-50.

Turner R, LangKamp-Henken B, Littell R, Lukowski M and Suarex M. Comparing Nutrient Intake From Food to the Estimated Average Requirements Shows Middle- to Upper-Income Pregnant Women Lack Iron and Possibly Magnesium. Journal of The American Dietetic Association. 2003;103:461-6.

University of Alberta Hospitals. Guide to Laboratory Services: Manual of Test Procedures. January 1994.

Utter AC, Nieman DC, Ward AN, and Butterworth DE. Use of the leg-to-leg bioelectrical impedance method assessing body-composition change in obese women. American Journal of Clinical Nutrition 1999;69:603-07.

Verma A, Boney C, Tucker R, and Vohr B. Insulin Resistance Syndrome in Women with Prior History of Gestational Diabetes Mellitus. The Journal of Clinical Epidemiology and Metabolism 2002;87:3227-35.

Vohr BR, McGarvey ST, and Tucker R. Effects of Maternal Gestational Diabetes on Offspring Adiposity at 4-7 Years of Age. Diabetes Care 1999;22(8):1284-91.

Wang Y, Storlien L, Jenkins A, Tapsell L, Jin Y, Pan J, Shao Y, Calvert G, Moses R, Hong L, and Zhu X. Dietary Variables and Glucose Tolerance in Pregnancy. Diabetes Care 2000;23(4):460-4.

Ward W, Johnston C, Beard J, Baneditti T, Halter J, and Porte D. Insulin Resistance and Impaired Insulin Secretion in Subjects with a History of Gestational Diabetes Mellitus. Diabetes 1985;34:861-869.

Weintrob N, Karp M and Hod M. Short- and Long-Range Complications in Offspring of Diabetic Mothers. Journal of Diabetes and Its Complications 1996;10(5):294-301.

Willett W, Manson J, and Liu S. Glycemic Index, Glycemic Load, and Risk of Type 2 Diabetes. American Journal of Clinical Nutrition 2002;76(suppl):274S-80S.
Wolever TMS and Jenkins DJA. Effect of Dietary Fibre and Foods on Carbohydrate Metabolism. In Spiller GA, ed. CRC Handbook of Dietary Fibre in Human Nutrition. 2nd ed. Boca Raton, FL:CRC Press;1993:111-152.

Wolever TMS, Jenkins DJA, Jenkins AL and Josse RG. The glycemic index: methodology and clinical implications. American Journal of Clinical Nutrition 1991;54:846-54.

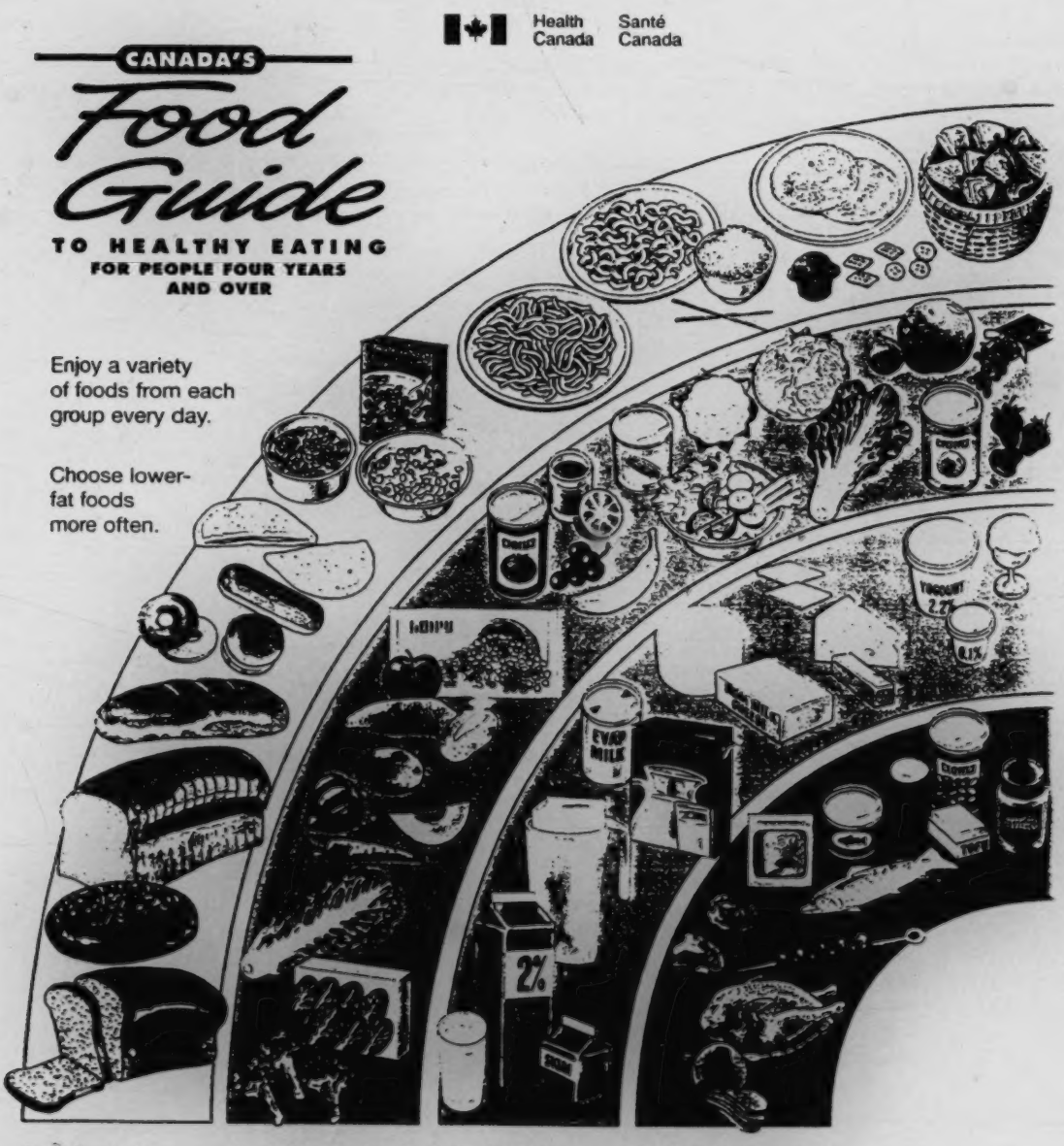
Wolever TMS. The Glycemic Index: Flogging a Dead Horse? Diabetes Care 1997;20(3):452-6.

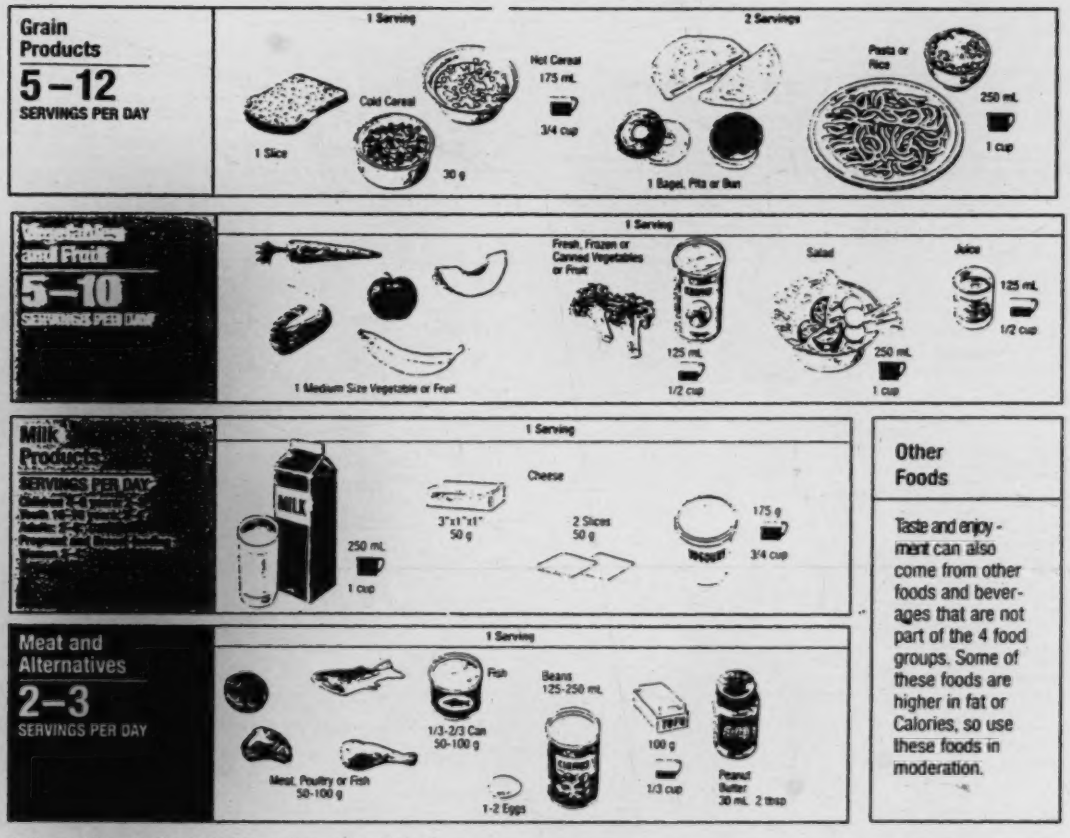
Xiong X, Saunders LD, Wang FL, Demianczuk NN. Gestational Diabetes Mellitus: Prevalence, Risk Factors, Maternal and Infant Outcomes. International Journal of Gynaecology and Obstetrics 2001;75(3):221-8.

Young CM, Franklin RE and Foster WD. Weekly variation in nutrient intake of young adults. Journal of the American Dietetic Association 1953 20:459-64.

Zulaika A and Alexis SD. Occurrence of Diabetes Mellitus After Gestational Diabetes Mellitus in Trinidad. Diabetes Care 1990;13(5):527-9.

Appendix A
Canada's Food Guide to Healthy Eating


Health Canada
Santé Canada
CANADA'S
Food Guide
TO HEALTHY EATING
FOR PEOPLE FOUR YEARS AND OVER
Enjoy a variety of foods from each group every day.
Choose lower-fat foods more often.
Grain Products
Choose whole grain and enriched products more often.
Vegetables and Fruit
Choose dark green and orange vegetables and orange fruit more often.
Milk Products
Choose lower-fat milk products more often.
Meat and Alternatives
Choose leaner meats, poultry and fish, as well as dried peas, beans and lentils more often.
Canada



Different People Need Different Amounts of Food

The amount of food you need every day from the 4 food groups and other foods depends on your age, body size, activity level, whether you are male or female and if you are pregnant or breast-feeding. That's why the Food Guide gives a lower and higher number of servings for each food group. For example, young children can choose the lower number of servings, while male teenagers can go to the higher number. Most other people can choose servings somewhere in between.

Enjoy eating well, being active and feeling good about yourself. That's VITALITÉ

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Cat. No. H39-252/1992E ISBN 0-662-19648-1
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NT04-83/00

Appendix F
Lifestyle Questionnaire - Baseline

FOOD AND NUTRITION INTAKE IN POST GESTATIONAL DIABETIC WOMEN

Health and Lifestyle Questionnaire (Pregnancy visit :1)

Patient and Family History

Name:_____

Date seen:_____

Study Number:_____

Phone:(H)_____(W)_____

E-mail:_____

Affix label here

Highest level education attained:

- ☐ Grade 11 or less
- ☐ Grade 12
- ☐ College
- ☐ Technical School (eg NAIT)
- ☐ University
- ☐ Higher University Degree

Ethnic background:

- ☐ Aboriginal
- ☐ African
- ☐ Arab
- ☐ Chinese
- ☐ Caucasian
- ☐ Asian Indian
- ☐ Hispanic
- ☐ Other _____

Do you work outside the home? ☐ Yes ☐ No

How many children do you have at home? _____

Annual Household Income (Optional):

- ☐< 20,000
- ☐ 20,000 - 40,000
- ☐ 41,000 - 60,000
- ☐ 61,000 - 100,000
- ☐ 100,000+
- ☐ Information declined

Smoking:

- ☐ Never
- ☐ Current if so, how many _____
- ☐ Previous if so, for how long _____
  when did you stop_____
- ☐ During pregnancy

FOOD AND NUTRITION INTAKE IN POST GESTATIONAL DIABETIC WOMEN

Health and Lifestyle Questionnaire (Pregnancy visit :1)

Do you have a known family history of diabetes? ☐ Yes ☐ No

If so,
- ☐ Mother
- ☐ Father
- ☐ Brother/Sister
- ☐ Grandparent - maternal
- ☐ Grandparent - paternal
- ☐ Other _____

How often do you eat away from home(ie at someone else's home)?
- ☐ 3 or more times/week
- ☐ 1 - 2 times per week
- ☐ sometimes
- ☐ never

How often do you eat in a restaurant?
- ☐ 3 or more times/week
- ☐ 1 - 2 times per week
- ☐ sometimes
- ☐ never

GDM Pregnancy

Parity P _____ G _____

Is this your 1st GDM pregnancy? ☐ Yes ☐ No

GDM pregnancy diagnosed at _____ weeks gestation.

Weight history

Current weight _____ Height _____

Pre pregnancy weight _____

Are you currently trying to lose weight? ☐ Yes ☐ No

In the past, have you ever tried to lose weight ☐ Yes ☐ No

If yes, how many times
- Total number times _____
- Number times before pregnancy _____
- Number times following a pregnancy _____

FOOD AND NUTRITION INTAKE IN POST GESTATIONAL DIABETIC WOMEN

Health and Lifestyle Questionnaire (Pregnancy visit :1)

Have you had any referrals to a dietitian for weight loss ☐ Yes ☐ No

For any weight loss attempts, how much weight did you lose? _____

Exercise

How often do you exercise?

- ☐ 3 or more times/week
- ☐ 1 - 2 times per week
- ☐ sometimes
- ☐ never

What type of exercise do you do (e.g. walking, running swimming, etc)?

Exercise type	Duration (amount of time per day or week)

Medication

Are you currently taking any medications? ☐ Yes ☐ No

If yes, type of medication are you taking:

- ☐ prescription
- ☐ vitamin/mineral supplement

If you are taking any of these types of medication, would you please list them below (use back of page if necessary):

Medication Type	Medication Name	Dose	Frequency
Prescription			
Vitamin/Mineral Supplement			

Appendix G
4-day Food Record Instruction Sheet

FOOD AND NUTRITION INTAKE IN POST GESTATIONAL DIABETIC WOMEN

4-Day Food Record

Directions for recording food intake:

- Please write down everything you eat and drink for the next 4 days.
- Include 3 weekdays and one weekend day.
- Record items just after you eat. Do not wait until the end of the day to write down your food intake.
- Include all meals and snacks (day and night) and any vitamins and dietary supplements that you take.
- Record all beverages, including tea, coffee, water and diet drinks.
- List each food on a separate line.
- Describe food items in detail and remember to include:
  - ✓ method of preparation(fried, boiled, baked, etc)
  - ✓ any fats used in cooking
  - ✓ any spreads such as butter, margarine or jam on bread or toast, sauces on vegetables or meat, dressings on salads, etc.
  - ✓ brand names when possible
  - ✓ for canned goods, liquid in which the item was canned (peach halves in syrup, tuna in water, etc)
  - ✓ packaging if applicable: frozen, canned, fresh
- Record amounts as ordinary household measures (weight, volume or dimensions). Be as accurate as possible.
  - ✓ "cup" can be used for items such as beverages, mashed potatoes, pasta, salad, casseroles, vegetables, puddings, etc
  - ✓ "teaspoon, tablespoon" can be used for spreads, jams, fats and oils, gravies, etc
  - ✓ dimensions as inch or cm can be used for items as cake, pizza, some meats (ie 1 in x 2 in x 3 in)
  - ✓ for meats, fish or poultry specify: cut (ie chicken wing), fat trimmed or not, bone in or not, with or without skin, any coatings

Food Record Example

Name: _____ Date: _____

[illegible]	[illegible]	[illegible]	[illegible]
7am	Orange juice	½ cup	frozen, reconstituted
	Cereal	2/3 cup	Corn flakes, XYZ brand with:
	Milk	1/4 cup	2%
	Toast	2 slices	XYZ brand whole wheat bread with:
	Peanut butter	4 tsp	Generic brand, smooth, low fat
	Egg	1 large	fried in 1 tsp butter
	Coffee	8 oz cup	with:
	Milk	2 tsp	2%
	Sugar substitute	½ tsp	Splenda
10 am	Apple	1medium	Spartan, 3 in diameter

Appendix H
Lifestyle Questionnaire – 6 weeks and 6 months Postpartum

FOOD AND NUTRITION INTAKE IN POST GESTATIONAL DIABETIC WOMEN

Health and Lifestyle Questionnaire (6 week postpartum visit)

Patient and Family History

Initials:_____

Date seen:_____

Study Number:_____

Phone:(H)_____(W)_____

E-mail:_____

Affix label here

Do you presently work outside the home? ☐ Yes ☐ No

How many children do you have at home? _____

Annual Household Income (Optional):
- ☐< 20,000
- ☐ 20,000 - 40,000
- ☐ 41,000 - 60,000
- ☐ 61,000 - 100,000
- ☐ 100,000+
- ☐ Information declined

Smoking:
- ☐ Never
- ☐ Current if so, how many _____
- ☐ Previous if so, for how long _____ when did you stop_____
- ☐ During pregnancy

How often do you eat away from home (ie at someone else's home)?
- ☐ 3 or more times/week
- ☐ 1 - 2 times per week
- ☐ sometimes
- ☐ never

How often do you eat in a restaurant?
- ☐ 3 or more times/week
- ☐ 1 - 2 times per week
- ☐ sometimes
- ☐ never

FOOD AND NUTRITION INTAKE IN POST GESTATIONAL DIABETIC WOMEN

Health and Lifestyle Questionnaire (6 week postpartum visit)

GDM Pregnancy

Diabetes control during GDM pregnancy:
insulin ☐ Yes ☐ No
If yes, _____ Units _____ X/day in last week of pregnancy
Gestational age of insulin requirement _____
How many weeks were you on insulin _____ weeks

Delivery: Full term ☐ Yes ☐ No at _____weeks

Type of delivery: ☐ forceps ☐ normal ☐ C-section

Neonatal complications: ☐ Yes ☐ No
If yes, what were the complications_____
_____

Infant birth weight _____lbs_____oz (_____ gm)

Did you breast-feed your infant ☐ Yes ☐ No
If yes, ☐ presently breast feeding
☐ breast fed for ___ weeks

Weight history

Current weight _____ Height _____

Weight gain during pregnancy to last recorded weight _____

Are you currently trying to lose weight? ☐ Yes ☐ No
If yes, for how long _____
So far, have you ☐ lost weight if so, how much _____
☐ gained weight if so, how much _____
☐ neither lost nor gained weight

Please describe weight loss program:
prescribed by: ☐ self
☐ health professional
☐ other (please describe)_____
_____

Does your program include ☐ diet only
☐ exercise only
☐ diet and exercise

FOOD AND NUTRITION INTAKE IN POST GESTATIONAL DIABETIC WOMEN

Health and Lifestyle Questionnaire (6 week postpartum visit)

Exercise

Currently, do you exercise? ☐ Yes ☐ No

If yes, how often do you exercise?
- ☐ 3 or more times/week
- ☐ 1 - 2 times per week
- ☐ sometimes

Do you participate in a formal exercise program? ☐ Yes ☐ No

What type of exercise do you do (e.g. walking, running swimming, etc)?

Exercise type	Duration (amount of time per day or week)

Medication

Are you currently taking any medications? ☐ Yes ☐ No

If yes, type of medication are you taking:
- ☐ prescription
- ☐ vitamin/mineral supplement

If you are taking any of these types of medication, would you please list them below (use back of page if necessary):

Medication Type	Medication Name	Dose	Frequency
Prescription			
Vitamin/Mineral Supplement			

FOOD AND NUTRITION INTAKE IN POST GESTATIONAL DIABETIC WOMEN

Health and Lifestyle Questionnaire (6, 12 month postpartum visit)

Patient and Family History

Affix label here

Initials:_____

Date seen:_____

Study Number:_____

Phone:(H)_____(W)_____

E-mail:_____

Do you presently work outside the home? ☐ Yes ☐ No

How many children do you have at home? _____

Annual Household Income (Optional):

- ☐< 20,000
- ☐ 20,000 - 40,000
- ☐ 41,000 - 60,000
- ☐ 61,000 - 100,000
- ☐ 100,000+
- ☐ Information declined

Smoking: ☐ Never
☐ Current if so, how many _____
☐ Previous if so, for how long _____
when did you stop_____

How often do you eat away from home (ie at someone else's home)?

- ☐ 3 or more times/week
- ☐ 1 - 2 times per week
- ☐ sometimes
- ☐ never

How often do you eat in a restaurant?

- ☐ 3 or more times/week
- ☐ 1 - 2 times per week
- ☐ sometimes
- ☐ never

FOOD AND NUTRITION INTAKE IN POST GESTATIONAL DIABETIC WOMEN

Health and Lifestyle Questionnaire (6, 12 month postpartum visit)

GDM Pregnancy

Did you breast-feed your infant ☐ Yes ☐ No
If yes, ☐ presently breast feeding
☐ breast fed for ___ weeks
☐ breast fed for ___ months

Are you currently pregnant? ☐ Yes ☐ No

Weight history

Current weight _____ Height _____

Are you currently trying to lose weight? ☐ Yes ☐ No

If yes, for how long _____
So far, have you ☐ lost weight if so, how much _____
☐ gained weight if so, how much _____
☐ neither lost nor gained weight

Please describe weight loss program:
prescribed by: ☐ self
☐ health professional
☐ other (please describe)_____
_____

Does your program include ☐ diet only
☐ exercise only
☐ diet and exercise

FOOD AND NUTRITION INTAKE IN POST GESTATIONAL DIABETIC WOMEN

Health and Lifestyle Questionnaire (6, 12 month postpartum visit)

Exercise

Currently, do you exercise? ☐ Yes ☐ No

If yes, how often do you exercise?
- ☐ 3 or more times/week
- ☐ 1 - 2 times per week
- ☐ sometimes

Do you participate in a formal exercise program? ☐ Yes ☐ No

What type of exercise do you do (e.g. walking, running swimming, etc)?

Exercise type	Duration (amount of time per day or week)

Medication

Are you currently taking any medications? ☐ Yes ☐ No

If yes, type of medication are you taking:
- ☐ prescription
- ☐ vitamin/mineral supplement

If you are taking any of these types of medication, would you please list them below (use back of page if necessary):

Medication Type	Medication Name	Dose	Frequency
Prescription			
Vitamin/Mineral Supplement			

Appendix I
(Calculation of Type 1 Error using paired T-Tests)

c=# of orthogonal comparisons
α_{PC}= 0.01/0.05

Using an Alpha p<0.01

$\alpha_{Type\ 1\ Error} = 1 - (1-\alpha_{PC})^c$

$\alpha_{Type\ 1\ Error} = 1 - (1 - 0.01)^6$

$\alpha_{Type\ 1\ Error} = 1 - (.99)^6$

$\alpha_{Type\ 1\ Error} = 1 - 0.941$

$\alpha_{Type\ 1\ Error} = 0.059$

Using an Alpha p<0.05

$\alpha_{Type\ 1\ Error} = 1 - (1-\alpha_{PC})^c$

$\alpha_{Type\ 1\ Error} = 1 - (1 - 0.05)^6$

$\alpha_{Type\ 1\ Error} = 1 - (.95)^6$

$\alpha_{Type\ 1\ Error} = 1 - 0.735$

$\alpha_{Type\ 1\ Error} = 0.265$

Method from Keppel & Zedeck, 1989